IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

A New Mod[illegible] Arctic [illegible]

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

November 1929

Mechanical Engineering

The Monthly Journal Published by

The American Society of Mechanical Engineers

Publication Office, 20th and Northampton Streets, Easton, Pa. Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-Ninth Street, New York

Volume 51 | November, 1929, Section One | Number 11

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Price 60 Cents a Copy, $5.00 a Year; to Members and Affiliates, 50 Cents a Copy, $4.00 a Year. Postage to Canada, 75 Cents Additional; to Foreign Countries, $1.50 Additional. Changes of Address should be sent to the Society Headquarters.

Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on January 17, 1921.

I. I. Sikorsky

A. M. Wahl

C. H. Berry

J. D. Wallace

M. S. Wallace

Contributors to This Issue

Vilhjalmur Stefansson, Arctic explorer, made his first trip to Iceland in 1904. The following year he returned again on an archaeological expedition under the auspices of the Peabody Museum of Harvard University. In 1906-07 he spent eighteen months on an ethnological expedition to study the Eskimos of the Mackenzie Delta. His next expedition (1908–1912), under the auspices of the American Museum of Natural History, New York, and the Government of Canada, lasted 53 months. He added to the map of Canada many new features, including the Horton River, over 500 miles long. From 1913 to 1918 he was in command of the Canadian Arctic expedition. In the spring of 1914, with two companions he made a 600-mile sled journey over broken and moving ice from Martin Point, Alaska, to the northwest of Banks Island, discovering new land north of Prince Patrick Island; in 1916 he explored islands already discovered, and found new ones west of Herberg Island and elsewhere. In 1917 he ran a line of soundings 100 miles northwest of Cape Isachsen, showing the polar ocean to be shallow in this region. Dr. Stefansson is a graduate of the University of Iowa, and has received the degrees of A.M. from Harvard University and LL.D. from the University of Michigan.

Igor I. Sikorsky, vice-president in charge of engineering of the Sikorsky Aviation Corporation, attended the Kiev (Russia) Polytechnic Institute. From 1908 to 1913 he designed and built several successful airplanes, one of which won the Petrograd Military Competition against several leading European designers. In 1913 he constructed and successfully flew the first multi-motored airplane in the world. From 1914 to 1917 he designed large bombers for the Russian Army. After the Russian Revolution in 1917 he worked with the French Government on similar types. Coming to the United States in 1919, he continued the design and construction of single- and multi-motored aircraft, forming his own corporation for this purpose.

C. H. Berry, professor of mechanical engineering in the engineering school of Harvard University, received his M.E. from Cornell University in 1912 and his M.M.E. in 1916. From 1913 to 1918 he served as an instructor and assistant professor at Cornell, resigning to become connected with the Detroit Edison Co. as technical engineer of power plants, with which organization he remained until 1925, when he became an associate editor of *Power*. In September, 1928, he assumed the duties of his present position.

A. M. Wahl, of the Research Department of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., received his B.S. in mechanical engineering from Iowa State College in 1925, and two years later his M.S. from the University of Pittsburgh. He entered the graduate-student course of the Westinghouse Co. in 1925, and in 1926 became connected with the Research Department.

J. W. Bowley was graduated from University College, Nottingham, England, and Queen's University, Kingston, Ont. He has served as an instructor in engineering in England, Canada, and the United States. During the war he was in charge of vocational training at Saskatoon, Sask., for the Military Hospitals Commission, Canada. In 1923 he became associated with the Westinghouse Elec. & Mfg. Co.

G. Back, after graduation from the University of Pennsylvania in June, 1921, was employed for two years as research assistant in vibration problems with the Vibration Specialty Co., of Philadelphia. In 1923 Miss Back became a member of the calculating squad of the turbine-engineering department of the South Philadelphia Works of the Westinghouse Electric & Manufacturing Co., eventually taking charge of it. In May of this year she received an appointment as research associate in the engineering mechanics section of the Bureau of Standards.

W. M. Coates, instructor in engineering mathematics, University of Michigan, received his A.B. from Williams College, and his M.Sc. in mathematics and D.Sc. in engineering mechanics from the University of Michigan. Previously he was an instructor in mathematics at the University of Virginia.

W. H. Holcomb, who writes in this issue on "The Development of the Deep-Well Turbine Pump," is manager of the pump department of the Pelton Water Wheel Co., San Francisco, Calif.

J. D. Wallace, president of J. D. Wallace & Co., received the degree of M.E. from Lewis Institute in 1909. In 1912 he founded the company of which he is now president. As the originator and inventor of portable direct-motor-driven woodworking machinery he has been continuously engaged in the design and production of that type of equipment for 15 years.

Margaret S. Wallace is the daughter of J. D. Wallace and a junior in the School of Commerce, Northwestern University. She carried out the exhaustive research necessary to prepare the paper submitted.

C. F. Hirshfeld, chief of the research department of the Detroit Edison Co., received the degree of B.S. from the University of California and his master's degree in mechanical engineering from Cornell University. Until 1913 he served as a member of the faculty of the latter institution, then becoming associated with the Detroit Edison Co.

This Month's Cover, used in connection with Dr. Stefansson's paper on "Flight in the Arctic Regions," shows the modern method of Arctic travel—an airplane on skis, as compared with that of the age-old dog sledge. The picture is one supplied by the Keystone Views.

MECHANICAL ENGINEERING

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A Pioneer in Engineering Education

Some Observations on the Notable Achievements of Robert Henry Thurston, First President of the A.S.M.E., as an Engineer, Educator, and Author[1]

ROBERT HENRY THURSTON, educator and mechanical engineer, was born on October 25, 1839, in Providence, R. I. The father, Robert Lawton Thurston, was a builder of steam engines and boilers, and with him, during college vacations and after graduation from Brown University, the son was associated as a designer. During the Civil War, the younger Thurston was an engineer officer in the United States Navy, but the return to peace-time conditions found him, on January 1, 1866, an instructor in natural philosophy at the Naval Academy, Annapolis, Md. When Stevens Institute was formed at Hoboken in 1871, Thurston joined its faculty as professor of mechanical engineering, serving fourteen years. In 1885 he became director of Sibley College, Cornell University, at Ithaca, N. Y. There, on October 25, 1903, suddenly and peacefully, in the midst of an active life devoted to the service of mechanical engineering and education, and marked with distinguished contributions to the literature and progress of his profession, he died.

Such is the stark chronology of a man's life. Each phase of this life, apparently so arbitrarily divisioned by time, was molded by heredity and environment to the inevitable purpose of the whole, and exhibits a logical development from the experience in design and construction in his father's business, through the period of operation and discipline in the Navy, to the fruitful years of research, professional practice, and teaching which came with maturity. It is impossible to detach this life, more individualistic than most, from the background of the times, from the broad evolution of industry and the emergence of engineering from the empiricism of technology into the rationalism of applied science.

A PORTRAIT TABLET TO DR. THURSTON

Dr. Thurston's life was deeply and firmly rooted in the past. The age into which he was born was grappling with a new type of civilization in which the machine and mechanical power had introduced revolutionary forces. A new type of educated, cultured man, the engineer, was coming into prominence as the displacement of the handicrafts by a machine industrialism developed the need for analytical minds to adapt science and technology to the new order of every-day life. Of this age Dr. Thurston was a vital part and a far-visioned leader.

His life was an honest stewardship of a unique inheritance. The actively inquiring mind, set in its sound, if not large and robust, body, the tradition of sober ideals of unselfish and constructive conduct, and the opportunity which his father's business afforded for contacts with the infant profession of mechanical engineering, its problems, and its distinguished practitioners, formed the heritage with which he was endowed. His administration of it, from early manhood to death in the lustihood of useful influence, was marked with an intense and unremitting activity and an eager search for truth which made him one of the foremost engineers and educators of his time.

In an outline of an autobiography on which he was at work when death overtook him, Dr. Thurston had laid out the principal topics of its final chapter. The last of these he called "The Quenching of the Torch;" and as a torch of patiently sought-out truth burning brightly in the darkness of ignorance and half-truths from which engineering is even now still struggling to emerge, the present generation may think of him. Whatever specific contributions there may be by which his friends and contemporaries knew him, the light which he shed upon our knowledge of the mechanical world and its adaptability

[1] "Robert Henry Thurston—A Biography," by Wm. F. Durand, Past-President A.S.M.E., will be published by the Houghton Mifflin Company early in November. A special subscription edition, bearing the Society's imprint, will shortly be offered to members of the A.S.M.E.

to the service of mankind will be accounted by those who read his biography his greatest claim to fame. Beams of this light, penetrating the dark avenues of the future, illuminated certain portions of it for prophetic scrutiny. He had confident faith that men would fly; his vision saw beyond his times in the development of steam power; his imagination pictured the role that management might play in production. No seer only, his acts gave substance to his ideas, to which the success of engineers, educated under his direction at Stevens and Sibley College, bears witness.

Thurston's Pioneer Work in Engineering Education

Dr. Thurston belonged to that group of pioneers in engineering education which laid the foundations of our present-day system. That the foundations were firm has been proved by a recent investigation which found it healthy and sound. Teachers of today will find it hard to understand the difficulties which confronted these early educators. With little but his own vision to guide him, Dr. Thurston laid out a curriculum for a mechanical engineering course which was sound in theory and a distinct departure from the pedagogic method of the day. He found no suitable textbooks, and was forced to make his own. The fundamental data upon which engineering designs are based—the properties of the materials of engineering—had not been coordinated and were woefully incomplete. He gathered and assembled such data as were available and devised the apparatus and technique necessary to supply the missing portions by his own investigations. He was zealous in research, that essential companion to truth, and introduced its spirit and practice into the teaching of mechanical engineering.

A keenness of observation brought favorable notice to Dr. Thurston in his early life in the Navy when he was ordered to give technical reports on war vessels, and became a valuable asset in research and in the writing of such other reports as that which he made as a member of the United States Scientific Commission to the Vienna International Exposition in 1873. Out of this ability to observe carefully and sense the meaning of what he saw grew such a specific contribution to knowledge as the phenomenon which he discovered and announced for the first time that repeated stress beyond the yield point raises the elastic limit of ductile materials.

Dr. Thurston as a Technical Writer and Investigator

Early in his career as a teacher, Dr. Thurston turned to technical writing. It was in the *Journal of the Franklin Institute*, of which Dr. Morton, later first president of Stevens Institute, was editor, that Thurston's first papers were published. He had a decided flair for this type of writing, and found time in a busy life to write extensively. His published papers brought him into prominence in this country and abroad, and formed the connection with Dr. Morton by which the two became associated in the unique adventure in engineering education worked out at Stevens. Made humble by a breadth of culture which gave perspective to his vision, he took of progress no arrogant view which failed to realize that it was evolutionary. Striking evidence of this may be found in that excellent book, "The Development of the Steam Engine," which grew out of the popular lectures given at Stevens and which remains today the best brief historical record of the development of steam power.

Men like Dr. Thurston placed the engineering schools with which they were connected in the fore of engineering progress. The laboratories of these schools were active in research and the teachers were serving not only their students but also industry and the profession as consultants. They served on commissions, were prominent in the work of engineering and scientific societies, and wrote many papers and books. Dr. Thurston's own contributions on the materials of engineering, the steam engine and boiler, friction and lubrication, were highly prized. Many demands and responsibilities in such an active life meant overwork, and a nervous breakdown which came while he was at Stevens served as a warning to Dr. Thurston to conserve his strength, so that the years at Sibley College were devoted more exclusively to education and less to engineering practice. During those eighteen years which brought his career to a close, his influence was extended to the lives of the young men who studied under him.

Engineering societies supplement the experience of college education. Dr. Thurston's connection with the formation of The American Society of Mechanical Engineers and his administration of its affairs as the first president is of especial interest to mechanical engineers. By them he has been duly appreciated and highly honored. His interest in the Society and his contributions to the Transactions helped to set a high standard for its ideals and a vision of its responsibilities, and to develop the very practical services which it has rendered to engineers.

A portrait tablet to Dr. Thurston in the rooms of the Society shows a man clothed in academic robes—which are a symbol of his services to education, his head supported by his right hand, an engineering instrument in his left. Keen, deep-set eyes look out past men and things into a region of thoughtful speculation. There is no indication of the impatience which the man sometimes expressed in the failure of his own times to make the advances he had envisioned for them. The spirit of philosophic detachment which emanates from this figure has a truer perspective and a more tolerant patience with progress. A torch which once shone brightly is quenched, but from its fire have caught other torches which scatter darkness and bring to an ever-widening horizon of engineering knowledge the truth and the light.—G. A. S.

The Training of Researchers

One thing I wish to say, and that is, to refer to the necessity for the training in the universities of a considerable number of engineering students with the research outlook. Training in strict habits of observation and in the investigation of problems theoretically and by experiment, should form part of the work of all engineering students. Much of the theoretical knowledge that a young engineer requires to learn is now to be found in excellent textbooks and in current periodicals, and these he should be taught to read critically and with understanding, but he should also be taught to face all his problems in the spirit of an investigator. Certain selected students should be encouraged to remain at the universities after graduation, or to return after some experience in actual works to engage specifically in research. Engineering needs such men, some to give their whole time to research, while others carry the spirit of research back into the ordinary problems of industry and engineering. Employers, public authorities, and governments must utilize this research ability. More men should find their way into industries from the research institutions. The universities, however, cannot do this most important work of training researchers unless they are adequately equipped and staffed to give members of the staff the necessary time for research and to devote themselves to the training of students in research. To this end, sufficient funds must be provided from private and public sources. In the solution of many problems in design, in processes, in materials, as well as in the discovery of new methods, it is necessary, as Francis Bacon would today remind us, "to apply natural philosophy to particular problems, and particular problems must be carried back to natural philosophy."—Prof. H. C. Lea before Section G of the British Association, Johannesburg, S. A., Aug. 1, 1929.

Flight in the Arctic Regions

Popular Misconceptions Regarding Arctic Conditions—Arctic Routes Between World Capitals of Northern Hemisphere Much the Shorter—Arctic Regions Peculiarly Favorable for Flying, and Especially So in Case Forced Landings Must Be Made

By VILHJALMUR STEFANSSON, NEW YORK, N. Y.

THIS is to be a synopsis of the story of the north temperate zone as the imagined, and in that sense real, prison of mankind. The prison walls are down but our movements are not free as yet, for we still drag with us some of the shackles fastened upon us by ancient Greek philosophy.

The Greek-derived civilization of the Middle Ages looked upon itself as imprisoned between a burning region to the south and a frozen one to the north, the torrid and the frigid zones. The tropics were supposed to be literally burning and boiling hot because of nearness to the sun, and the frigid zone forever lifeless because of distance from the sun.

The late medieval navigators, inspired, cajoled, and driven by Prince Henry of Portugal, finally ventured into and later crossed the tropics, so that the supposedly boiling seas were conquered by wind-driven ships. The beginning of that conquest was when Prince Henry got the idea that possibly tropic heat might not be so great as the scientists of his day believed. That was in the early part of the fifteenth century. The equator was crossed by the middle of that century and the whole torrid zone before its end, with the rounding of Africa by Da Gama and the discovery of a sea road to the Indies.

The Conquest of the Frozen North

The conquest of the "frozen north" has taken more time. Knowledge for breaking it down began to be accumulated when the Irish discovered Iceland around 790 A.D., thus extending the bounds of known animal life 600 miles beyond Scotland, once assumed by the Greeks to be the northern limit of bird or beast. Then followed the discovery and colonization of Greenland; the discovery and cultivation of Spitsbergen fisheries; and, after centuries, the modern era of polar exploration from Willoughby, who practically died of fright with all his men, paralyzed by his dread of the slightly real but chiefly mythical terrors of the north, to Peary, who, within the memory of some of us, finally arrived at the conclusion that the winter is the best season for Arctic work, that the coldest months are the best travel months of the winter, and that success up there is to be attained by reversing practically every medieval idea of Arctic principle and procedure.

You of The American Society of Mechanical Engineers, and people like you in many lands, are in control of these marvelous devices of emancipation—the airplane and the airship. You are living on a spherical world, with some of your most important cities so located that the shortest distance between them lies across the Arctic. Emancipate yourselves from that fear of the Arctic which you inherit from the Greek philosophers who equally feared the tropics. The real Arctic is peculiarly favorable for flying while you are in the air, and it is the most favorable natural terrain in the world for landing if you have to come down. The Arctic is the smallest of the oceans, and there are better island bridges across it than across any of the other oceans.

You are bound to discover these things piecemeal during the next ten or twenty years. It would no doubt be thrilling to have each discovery a separate revelation. But would it not be still more thrilling, both as a discovery and as a business adventure, to break down the whole wall of Arctic superstition in some such short period as the next five years? You can do that if you will put aside your household, school, college, and newspaper folklore and address yourselves to what the conditions really are. Make use now of the tools which the Lord gave you through the hands of the Wrights and Zeppelins, and of the conditions which He gave you to direct.

Peary, the great pioneer of Arctic travel, has passed into history, but Nansen, the great pioneer of scientific studies in the North, though he began his career before Peary, is still not only living but active.

However, the transportation conquest of the Arctic that parallels Henry's subjugation of the tropics does not come from travelers and scientists of the Arctic sphere proper, except incidentally. It comes directly from the work of the two great air pioneers, the brothers Wright, one of whom is still with us at the height of his career and sits at this table tonight, at once the chief reason for and the chief ornament of your important gathering.

When Prince Henry got the idea that the tropics might not be burning hot and that his own men could sail them in wooden ships, he broke the south wall of the medieval prison of our European civilization. When Orville and Wilbur Wright first put into workable form the idea of controlled flight in heavier-than-air machines, they broke every physical transportation barrier that remained. For the ocean of the air, unlike the liquid seas, is without a shore and without a hindrance in any direction. True, there still remains a mental barrier, the inherited medieval belief in fearful Arctic cold and prohibitive storms that would keep even flying machines at bay. The foundations of that belief had really been destroyed by the Pearys and Nansens before ever the Wrights flew, but the public does not realize that yet. Such barriers last as long as you believe in them.

It does remain a deplorable fact that the new knowledge of favorable Arctic flying conditions, although far more conclusive than Darwin's evidence when he marshaled anew the theories of evolution, has had as yet no more practical effect upon the thoughts and plans of leaders in aviation than the Darwinian views have thus far had upon Arkansas and Tennessee.

There is little time for exposition in a forty-five-minute talk, so let us state categorically some things, for which you can easily find proof if you like, reminding yourself, too, that there are many other pertinent facts and principles like them which we haven't the time to mention.

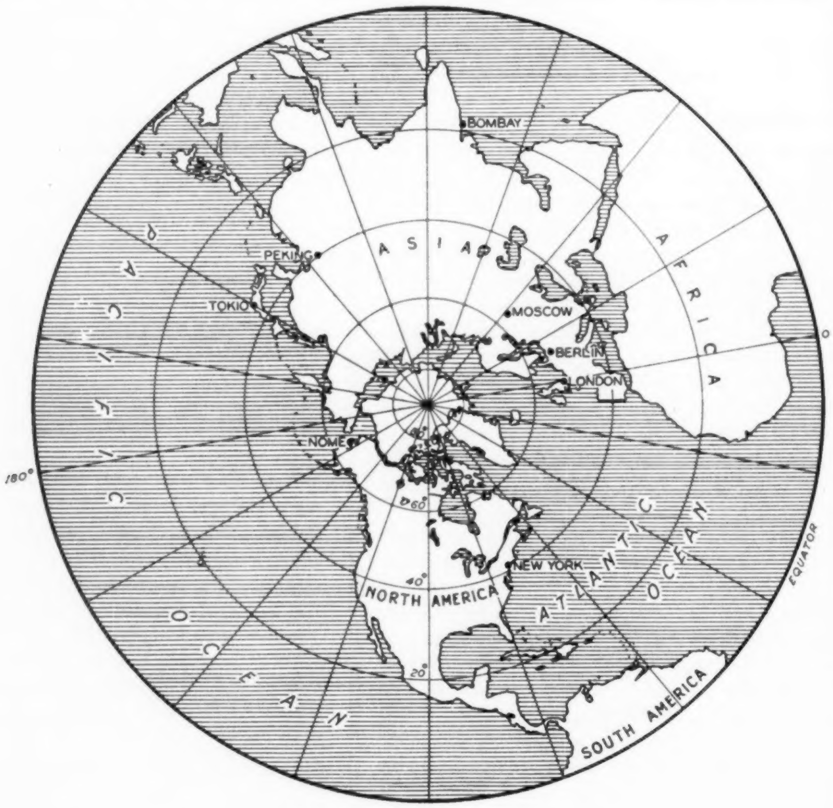
Arctic Temperature and Daylight Conditions

The polar sea, which means two-thirds of the Arctic, has six or ten feet above it in winter a temperature that is never lower than

Address delivered at banquet during the Third National Meeting of the A.S.M.E. Aeronautical Division, St. Louis, Mo., May 27 to 30, 1929.

60 below zero and very seldom as low as 50 deg. There is already successful winter airplane flying in places like the Yukon Valley, Alaska, where you take off at temperatures ten to twenty degrees colder, say, 60 to 70 deg. below zero. In winter, moreover, there is in the Arctic on cold days, generally prevalent both over the land and the sea, the condition of inverted temperatures. The Lomen Reindeer Corporation, for instance, employs airplanes in tending its herds and reports that they frequently find half a mile above the ground a temperature from thirty to fifty degrees warmer than the ground record either at the take-off or landing.

There is a little more daylight in the Arctic per year than in either the tropic or temperate zones, by reason of refraction and other well-known laws. The moon delivers more light at the



THE NORTHERN HEMISPHERE

earth's surface in the Arctic than in any southerly places, for the air is comparatively free from dust and moisture and the full moon is longer above the horizon. Then the ground in the Arctic is green or black only in the summer when there is abundant sunlight, while in winter when the sun is low or absent the ground is white with snow, so that the moonlight and starlight are brilliantly reflected and each is something like doubled in effectiveness thereby. Further, there is a peculiar source of light, the aurora, which on most still nights has a light value at least equal to half the total starlight, with sometimes double or quadruple the power of all the stars. With no aurora and only half a moon you can see mountains indistinctly if their tops are above the horizon. With a full moon you can see the remotest mountains with the clarity of daylight. Nor is there ever a pitch darkness even when there is no moon above the horizon, though the sky be thickly overcast. Down here, under those conditions, you might not see a man dressed in black more than a few yards away, but would see him on the Arctic landscape several hundred yards away.

So far, then, as concerns working light in any part of the earth, the Arctic is better off than either tropics or temperate zones.

Other things being equal, the sun delivers as much heat at the earth's surface in twenty-four hours in the Arctic as it does in the tropics for a few weeks in midsummer. You therefore have tropical heat in the Arctic midsummer. By things being equal we mean that if you have both in the tropics and Arctic a low flat, humid land, free from desert conditions and far from mountains or sea, you will have maxima of 90, 95, or 98 deg. in the shade in both places. The difference is, of course, that when the wind changes to blow from the sea there is a drop in the Arctic temperature far greater than any drop that could occur in the tropics when a sea wind comes up.

It is for these reasons that weather bureaus located on low flat land in the Arctic and remote from the sea frequently record temperatures of about 90 deg. in the shade, and sometimes up to 100 deg.

Remember now a few things together: the terrific downpour of the Arctic sun in midsummer, that plants grow by light rather than by heat, and that they work by hours of daylight rather than by days of the calendar. You will then see how reasonable it is that an Arctic plant may grow more in a twenty-four-hour shift than an equatorial plant can grow in its single twelve-hour shift. This shows that the fact of green things growing rapidly in the Arctic is just as reasonable as facts are typically wont to be.

The heat and light being adequate, there is on the average as much vegetation per square mile in the Arctic as there is, for instance, on those Texas lands that are too dry for wheat and are therefore used for cattle. This explains why there are grass-eating wild animals all over the Arctic lands, except where they have been exterminated by European hunters. Similar facts explain the rich abundance of life in the polar sea.

The traveler returned from the North is frequently asked to say whether it is not remarkable that the animals do not freeze to death in that dreadful climate. The partial and inadequate answer is that the climate is not nearly so dreadful as the kindergarten and school-geography folklore would have us believe. The adequate answer is that reindeer not freezing to death is just as remarkable as codfish not getting drowned, which is only another way of saying that each animal prospers best in its native environment. There are millions of animals that are as native to the Arctic as a crocodile is to an African swamp.

If you check up on these assertions, and a few more of the same sort for which we have no time, you will perhaps come to the same conclusion that I did after spending the first six of my eleven years in the Arctic—that about 70 per cent of what I had learned in school and college about the Far North was either untrue or misleading. Perhaps the simplest way of arriving at a passable view of the Arctic is to remind yourself of what the public generally believes, and then assume the opposite. You will not be wholly right, but you will not be nearly as wrong as the man in the street.

I realize that no ordinary audience ten or twenty years out of college is in a frame of mind to accept so wholesale an indictment

of the education of ten or twenty years ago without much proof and argument. I do not expect such acceptance even though you are not an ordinary audience. There are a few among you, however, who have looked into these things already and know them to be as I have just stated. For the rest my hope is that those of you who do not forget the subject entirely in the press of things more important to you will follow along the indicated trail of skepticism and will investigate. I could deal with the subject adequately if I had four or five evenings instead of forty-five minutes. Beyond this, I can say only that I have dealt with the facts and with every objection to them I could think of in a series of voluminous books.

Advantages of Arctic Flying Routes

Having lengthily considered things not directly applicable to Arctic flying, we turn now to those that are directly in our path.

The basic Arctic flying consideration is that the wealth and power of the world are at present generally concentrated in cities that are in the northern hemisphere. (See small map on preceding page.) If you look on a globe you will see that the north temperate zone is in a circle around the Arctic, like the doughnut around its hole. If you break the doughnut in half, the hole is evenly divided between the two parts. Similarly, if you fly straight from New York to Peking you will fly north across the middle of the Arctic gap in our world of business cities. If you fly from Seattle to Moscow you will cross the gap without bisecting it. Flying approximately straight from St. Louis to Paris, you go by way of Chicago, Ontario, Labrador, Greenland, Iceland, Scotland, and London. On all these flights and on many others you have four advantages over the longer routes: you save miles; you have better weather conditions on the average; you have more natural landing places while you are over land; you have shorter jumps across water.

Three Advantageous Arctic Flying Routes

The large map on this page shows three flying routes, the

A Typical View of the Ice Pack Far From Land
(The view shows rough ice where no landings can be made, level landing ice for skis, and in the distance open water for flying-boat landings, with again rough ice beyond.)

first from New York to Peking, branching off if desired to Tokio. On this route from Cochrane, Ontario, to Nome, Alaska, the greatest flying altitude to be safe from all obstructions in a fog would be 4000 ft., while a 1500-ft. elevation would be ample over 95 per cent of the route. Again, between Cochrane and Nome one would never be five miles away from a good landing place for floats in summer or skis in winter. I have no doubt the conditions are about equally good through Siberia. The crossing of Bering Straits is about 75 miles, and could be made less by going a few miles out of the way.

The route from Chicago over Cochrane, Ontario, and by way of Baffin Island, Greenland, Iceland, and the Faroe Islands to Scotland is not quite so good, but is nevertheless the only practical route, or at least the most southerly practical route for air commerce between the United States and Europe. The same route from New York would join up somewhere in Quebec or in Baffin Island. The one from Seattle to England would join in Baffin Island. And so with other routes. East of the Rockies no altitude of more than 3000 ft. would be required till Greenland was reached, which must be crossed at an altitude of about 7000 ft. After that no high altitudes are required. The longest over-water jump is 400 miles—from Iceland to the Faroe Islands.

The route from Seattle to Moscow requires no high altitudes after crossing the Rockies—perhaps 4000 or 5000 ft. in Ellesmere Island. The longest over-water jump is about 600 miles, from Greenland to Spitsbergen and again from Spitsbergen to Norway. Sir Hubert Wilkins (see "Flying the Arctic," G. P. Putnam's Sons) considers the flying conditions on the average better on this route than on the Newfoundland-Ireland route as to air. He says he was never out of sight of a good landing place the whole way from Alaska to Greenland. Between Greenland and Spitsbergen the ice is so badly broken up that one might or might not find emergency landings. Between Spitsbergen and Norway regular North Atlantic conditions are encountered, with no chance of a safe landing. This part of the flight, in other words, would be as dangerous as a 600-mile jump across any other ocean.

The time being prohibitively short, I must say here that if you want a careful study and proof of all of these and many other pertinent things, you would do well to read two books that treat of them. One, "The Northward Course of Empire," written by myself and published in 1922, deals with the natural conditions and forecasts the flights which had not then been made. The other, "Flying the Arctic," by Sir Hubert Wilkins, published six years later, deals with the same natural conditions and with the flights as accomplished fact.

Perhaps the least obvious of northern flying advantages is that of numerous landing places. Their great number when you are over land results from the ground's being frozen so that there is no subsoil drainage. As a result, the typical Arctic country has ten times as many lakes as you would think natural anywhere else. Mountains are rare in the Arctic, and it is only among mountains that you may be for a time beyond sight of a good landing field. Anywhere else you can come down when you like with water gear in summer and with skis in winter. This great number of land-

Rolling Arctic Prairie
(From 10 to 50 per cent of these grassland areas are lakes. One would hardly ever be 5 miles away from one of them.)

ing places is the chief reason why in all of the tens of thousands of miles of Arctic flying in Canada and Alaska there has been no loss of life nor even a serious crash of an airplane. The most serious northern crashes known to me took place on a prepared landing field in Fairbanks, Alaska, which is, as a matter of fact, outside the Arctic. But, as many know, some of them present in this audience tonight, those crashes had nothing directly to do with any conditions that differ materially from those found every winter in Michigan or New York.

Level Arctic Prairie, Sometimes Called Tundra or Barren Ground
(From 25 to 60 per cent of these grassland areas are lakes. All these lakes are safe landing places in winter for skis; in summer discretion has to be used as to depth, but plenty of them are deep enough.)

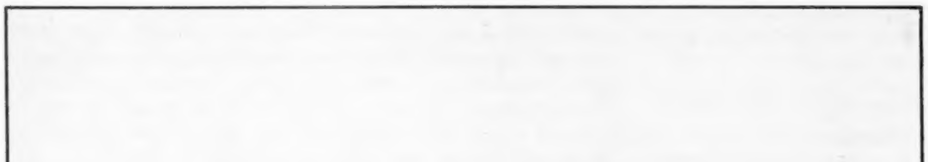
On the Atlantic, or in any other ocean except the Arctic, you have to be rescued after a forced landing or you will be drowned. True enough, there have been eminent Arctic explorers who have said that the same thing would happen in the Arctic. The most famous of them, with most authority, is Captain Amundsen, who said, both before he flew across the Arctic and afterward, in speeches, signed articles, and books, that there was no landing place for skis on the floating Arctic pack. To this there were from the beginning of the argument the directly opposed opinions of people like Captain Wilkins and myself. Today we have also the decisive experience of those who have tried.

Wilkins, piloted by Ben Eielson, made three forced landings in 1927. The first, in good weather, was 550 miles from land where the ice was floating upon water more than 17,000 ft. deep. This proved a safe landing with an easy take-off when engine trouble had been overcome. The second was 540 miles from land in blizzard and falling snow, a safe landing but with a take-off successful only after several attempts because of the rapidly accumulating and sticky, soft snow. The third landing, a hundred miles from shore, came when fuel ran out two hours after dark and in a thick blizzard. This landing was also safe, though that was a blessed chance, for no one will maintain that every spot is level on the floating pack.

Forced Landings Not to Be Feared in the Arctic Area

There is no record of forced landings followed by safe take-offs at distances hundreds of miles from shore in any ocean but the Arctic, nor do we see a probability of them hereafter.

After the forced night landing on the pack, Wilkins and Eielson walked around to get their blood in circulation and then retired to the cabin of their plane for a sound sleep. The next morning they found themselves drifting on a floe that continued drifting for 161 miles in three days, luckily parallel to the land instead of away from it. When the wind and current stopped, temporary frost bridges joined up the floes and Wilkins and Eielson walked ashore, eighty-nine miles in eleven days, with no serious difficulty. That you certainly could not do on the Atlantic or the Pacific.



Level Sea Ice During the Spring Break-Up, Showing Narrow Lead
(There are thousands of square miles of ice of this sort in smaller and larger patches scattered over the polar sea.)

No one claims that the Arctic is fool-proof or even that it is apprentice-proof. Before you begin flying there you should have the sort of training that Wilkins had, several years of actually helping himself and meeting Arctic conditions through the combined resources of precept and his own ingenuity.

I have a higher opinion than most of Nobile and his expedition, not being greatly swayed by the propaganda for him while everything went well nor the propaganda against him when the catastrophe had be-

fallen. But if you assume, as some have done, that Nobile and his men were incompetent, then the testimony of their experience becomes that much more favorable to the Arctic. They were pitched out upon the ice from a dirigible as if they had been thrown from a bucking broncho. If they had fallen into the Atlantic they would have drowned within forty-eight minutes. But what happened was that they prowled around on the ice and were picked up after forty-eight days.

Babushkin's Testimony

In connection with the Nobile rescues, the most valuable testimony from an aeronautical point of view comes from a vessel few of you remember and a man whose name you may not have heard, for it was seldom in the papers—the ship was the Russian ice breaker *Malygin* and the flier was Babushkin. A typical account in a book which has not yet been published in English is something like this: "We steamed up alongside a likely floe, lowered the airplane to the ice, Babushkin got in, taxied away and flew off, returning after an hour's reconnoitering. Conditions looked good, so he took off for a more serious flight, planning to be gone six hours. He was gone that length of time, but before he returned so thick a fog set in that when he got back he could not see the black smoke we made, though we could hear him circling over our heads, nor could he hear the sirens. He flew off and the sound of his motors was lost to us. Eighteen hours later he returned when the weather cleared, reporting that when he had given up finding the ship he had come down finally upon a floe in the thick fog and had stayed on it till the weather improved so he thought he could find his way back."

You will understand I am not quoting really, only summarizing as I remember it the story of a typical flight. You will find when the book is published that there are something like ten or a dozen such accounts. Babushkin went off again and again, sometimes returning in a few hours if the weather was good. Sometimes he was gone for several days, and at least half of his dozen landings were made on the drifting pack in the thickest fog. Yet they were all safe, as well as the take-offs. Finally the slight injury came. It was one that could have been repaired easily had there been a machine shop available.

Remember, the Babushkin flights were done in the worst time of year, the summer, when the ice in addition to natural roughness from the previous winter is corrugated with rivulets of rain and sea water. Moreover, this was on the edge of the pack, which all authorities agree is rougher and in every way less favorable than floes that are more centrally located.

The Real Arctic Peculiarly Favorable for Flying

You of The American Society of Mechanical Engineers, and people like you in many lands, are in control of these marvelous devices of emancipation—the airplane and the airship. You are living on a spherical world, with some of your most important cities so located that the shortest distance between them lies across the Arctic. Emancipate yourselves from that fear of the Arctic which you inherit from the Greek philosophers who equally feared the tropics. The real Arctic is peculiarly favorable for flying while you are in the air, and it is the most favorable natural terrain in the world for landing if you have to come down. The Arctic is the smallest of the oceans, and there are better island bridges across it than across any of the other oceans.

You are bound to discover these things piecemeal during the next ten or twenty years. It would no doubt be thrilling to have each discovery a separate revelation. But would it not be still more thrilling both as a discovery and as a business adventure, to break down the whole wall of Arctic superstition in some such short period as the next five years? You can do that if you will put aside your household, school, college, and newspaper folklore and address yourselves to what the conditions really are. Make use now of the tools which the Lord gave you through the hands of the Wrights and Zeppelins, and of the conditions which He gave you direct.

It took Prince Henry and the Portuguese a century to remove from men's minds the imaginary terrors of the Boiling Tropics, but they worked with little help from newspapers and books in an age of sails and rowlocks. By propeller, wing, and balloon, and by news through wire and wireless, you can remove the imaginary terrors of the world in five years if you begin to fly direct toward every transportation objective, whether it is across the Tropics or the Arctic. Winds that are head or fair may then induce you to bend your course as they do now, but you will no longer be controlled in your journeying by groundless fears of North or South. This will be the aeronautical conquest of the whole earth.

Did John Napier Invent Logarithms?

In 1904 H. Poincaré published a letter under the heading "La Terre Tourne-t-elle?" in which he explained a point of view according to which the rotation of the earth cannot be regarded as an established fact, but he emphasized at the same time the desirability of assuming that the earth does rotate, since this assumption is a fundamental harmonizing factor in our scientific thinking. Similarly, the heading of the present note aims merely to emphasize a point of view according to which one might be inclined to say that John Napier did not invent our common logarithms, since the nature of Napier's contributions becomes much clearer if it is viewed also from this standpoint.

The term "logarithm" itself, which Napier applied to his tables, points to a wide difference between the use he had in mind and our present common view of the main use to be made of logarithmic tables. The term "logarithm" means ratio number, and Napier's tables were invented with a view to their usefulness in working with ratios, especially with the equality of ratios, or proportions. Hence the fundamental laws that the logarithm of the product is equal to the sum of the logarithms of the factors and that the logarithm of 1 is 0 do not apply to his tables. These facts suffice to exhibit a very wide difference between his tables and our modern logarithmic tables, and they seem to justify the heading noted above.

It is true that Napier expressed some views relating to logarithms which were not embodied in his tables, but these tables are commonly called the earliest logarithmic tables, and the claim that Napier is the inventor of logarithms has been largely based thereon since the theory of logarithmic computation was developed by earlier writers, especially by N. Chuquet and M. Stifel. In fact, traces of this computation are found in Euclid's "Elements," and more explicitly in the work of Archimedes. If we regard the terms of the arithmetical series which Archimedes associated with a geometric series as the logarithms of the corresponding terms of the latter series, it results that the logarithm of the product of two factors is equal to the sum of the logarithms of these factors diminished by the logarithm of 1, which is not 0, just as in Napier's tables.

It is, however, not our main object to prove here that the question noted in the heading should be answered in the negative, but to direct attention to another clear illustration of the general principle that many scientific questions which are commonly answered in the affirmative may be greatly clarified by considering also the negative thereof. Historical questions seem to be especially adapted to be presented in the form of disputations, since the negative side of commonly accepted views is more likely to become clear when presented in this manner.—G. A. Miller in *Science*, July 26, 1929, p. 98.

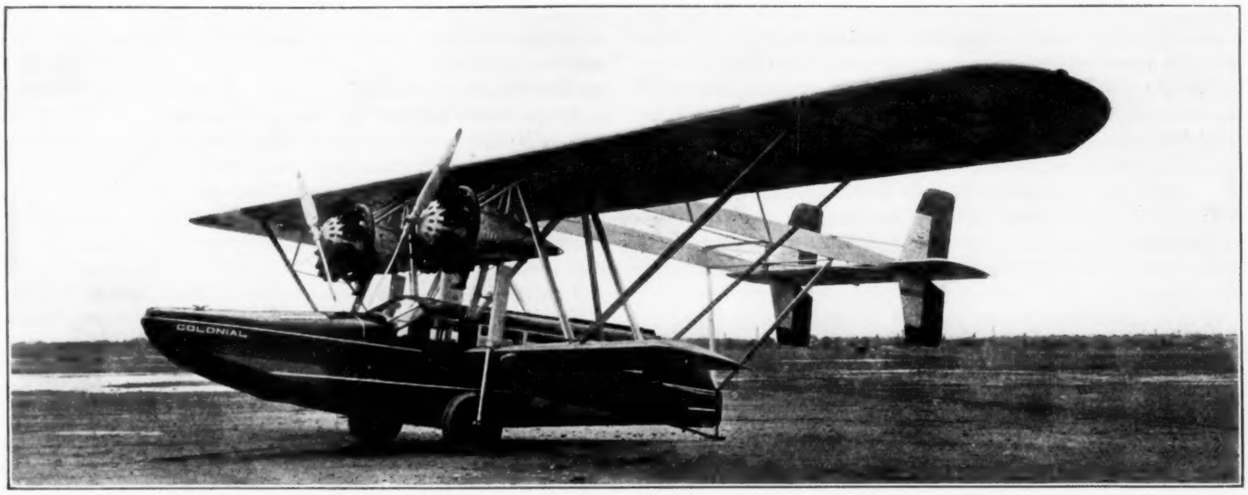


Fig. 1 One of Several Sikorsky Amphibion S-38's in Regular Service Between Buffalo and Toronto

Some Aspects of the Seaplane and the Amphibion

By IGOR I. SIKORSKY,[1] BRIDGEPORT, CONN.

NOT long ago, the first and main requirement of the airplane was performance. The l/d ratio of the plane, speed, load versus horsepower, and similar characteristics were the first, and quite often the only ones, to be considered when judgment of good or bad airplanes was pronounced. Performance still remains the main factor for most types of military aircraft, for racers, or for planes built for special purposes. However, for the general mass of privately owned aircraft, or air liners, performance is now only one of several components of the main factor, which may be called practicability.

The amphibion airplane is probably the most difficult to design and to build. It must remain less efficient from the standpoint of performance when compared with the land or sea plane. However, from the standpoint of actual service rendered it presents a considerable advantage in many cases. Especially as a privately owned craft will the amphibion be more useful than any other type. At present the amphibion is still only at the beginning of its career; there are considerably fewer practical types in existence as compared with the number of successful types of land and sea planes.

To the many honors which belong to this country in aviation, it seems justifiable to add that of creating the first practical amphibion. The Loening plane, originated several years ago, was undoubtedly the first amphibion which actually performed well, accomplished several long journeys, and, in general, proved to be entirely successful.

Difficulties Presented in Design of Amphibion

During the development period of aviation, the landplane came first; the seaplane, which presented greater difficulties, followed several years later, while the still more difficult and complicated amphibion became practical only after the conclusion of the war. The main difficulties with the amphibion, as compared with the seaplane, are the following:

1 The necessity of carrying the extra weight of the landing gear.

2 The necessity of taking care of the extra parasite drag of the landing gear.

3 The mechanical difficulties of the design of the landing gear.

4 The aerodynamic and the still more important general interference of the different parts of the plane.

The first two items are self-explanatory. As a matter of figures, it may be mentioned that on the S-38 amphibion, built by the author's company, the landing-gear weight is about $5^1/_2$ per cent of the gross weight, or almost 14 per cent of the useful load. The parasite drag is about 9 per cent of the whole parasite resistance of the plane, both figures being very substantial. The amphibion landing gear must fulfil all landplane requirements, and must permit a quick and easy raising and lowering of wheels by the pilot, as well as reliable fixing of the whole mechanism for landing on the ground. The most serious problem to be solved by the designer, however, is that of the general mutual interference of the main items of the amphibion. Let us consider a few examples. The boat hulls, or floats, in amphibions are much larger and heavier than the wheels. Therefore generally the wheels are made movable up and down or retractable. The whole floating equipment remains fixed to the structure of the plane. This creates difficulties. The clearance from propeller tip to the water must be greater than that necessary when above the ground. In the case of the amphibion, the plane with proper clearance on water becomes too high on ground, and this inconvenience should be compensated properly by some other characteristics of the design. There are a large number of mechanical problems connected with the proper combining of main parts, because the landing gear when raised may interfere with some structural members.

No general rule can be suggested for overcoming these diffi-

[1] Vice-President, Sikorsky Aviation Corporation.

Presented at the Great Lakes Aeronautic Meeting, Cleveland, Ohio, August 31, 1929.

culties, but the success of a design depends mainly on a happy and correct combination of different units and members. The problem of balance in the landplane consists chiefly of the proper combining of the wings and tail surfaces with the center of gravity of the plane, and the location of the wheels in the proper place for correct balance on ground. In the amphibion there is a third condition, stability on water, and the combination of the three is often much more complicated. The lateral stability on water is ordinarily provided in a single-float seaplane, or in a flying boat, by side floats, their shape, size, and position depending entirely upon the structure and place of attachment and the desired action on water.

In the amphibion, again, another condition must be satisfied, namely, protection of the float from damage when landing on ground. This may require placing the floats higher than would be desirable for water performances only, and therefore another problem must be solved—that of finding the shape and position for the float which will provide the necessary stability on water and yet leave the float in a safe position while landing on ground.

Requirements to Be Satisfied in Design

These are a few problems connected with the design of an amphibion, but, as a matter of fact, the whole design and almost every detail of the plane must satisfy a larger number of requirements than do those of other types of planes. The brakes must be protected from the action of salt water when the wheels are submerged after the plane is taxied in the water, otherwise the wheels may freeze and cause trouble when landing on ground. Finally, the tail skid should be especially designed and given much thought in order to reduce the drag in water during the take-off.

These problems are serious, but the wonderful progress of modern science and technique in aviation permits their proper solution. The achievements of aerodynamical laboratories and scientific institutions such as the N.A.C.A. and the Bureau of Standards, as well as considerable improvement and reduction in the weight of airplane engines, have made possible the wonderful success of aviation during the past few years, not the least of which was the construction of a practical amphibion.

Advantages Offered by the Amphibion

1 Every airport, as well as every harbor, lake, or river, represents a landing field. Therefore a better chance is offered to approach the hearts of cities, residential sections, and other centers of human activity, because these places are, in nine cases out of ten, adjacent to a navigable body of water. This is a considerable advantage. The privately owned craft, the aerial taxi, and the air liner can use water for taking off and landing passengers whenever this is desirable, but for parking, refueling, and maintaining the craft, airports will offer best advantages. Also, small amphibion taxis could contribute materially to the success of long-distance air lines by taking passengers to and from air terminals, and bringing them to some water landing which, in most cases, might be located much closer to the heart of a city than a landing field. This service could be introduced with advantage in such cities as Cleveland, New York, Washington, Philadelphia, and Chicago, or for that matter in almost every large city in the world.

2 Safety in case of a forced landing. Such landing, due to engine failure, occurs very seldom with reliable modern engines, and with multi-motored planes it can practically be disregarded. But another and more serious cause is bad weather. There seems to be no doubt that the powerful multi-motored air liner, with a large, scientifically educated, and well-trained professional crew, equipped with wireless and all reliable instruments which science has placed at their disposal, will maintain service in bad weather with the regularity of the best modern steamships. But it is, and for a very long period will remain, quite different in the case of the non-professional private owner and of the aerial taxi driver. There will be tens of thousands of such in the near future, and considerably more later on. The best thing they can do in case of fog or storm will be to look for a landing place, bring their craft down, and wait for better weather. In this case the pilot of an amphibion has in most places considerably better chances, for the water surface is easier to distinguish in bad visibility or when it becomes dark. Moreover, the majority of land is privately owned.

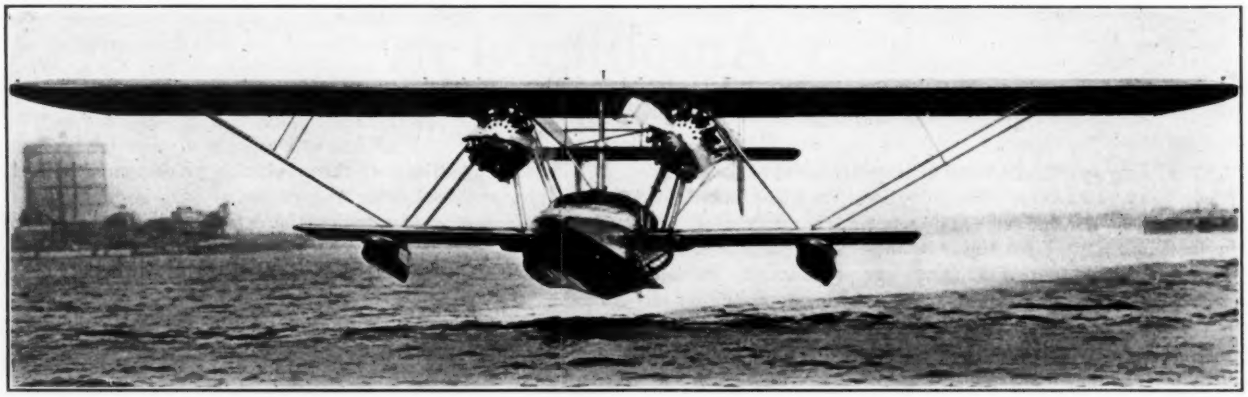


Fig. 2 Taking Off From the Water

In the immediate future, and in many cases right now, the airplane already has ceased to be an interesting novelty and is regarded just as any other vehicle. Landing on private property, therefore, will often be followed by a bill for damages. Quite recently a plane overshot a field and ran on a golf course. As a result a bill of over $300 was received and paid. This situation will become more general and will be heavily felt by every private flier, who will often try to avoid it, and take a chance on reaching a public airport even if something is wrong with the weather or with his plane. It is well known that a considerable number of serious accidents have been the result of minor defects, combined with the ardent desire of the pilot to reach, at any cost, the airport, thus avoiding an intermediate landing with a possible small damage to the plane. The pilot of the amphibion, from all these standpoints, is in a much better position. At his disposal there is, in most parts of the country, an abundance of emergency water landing places. Taking, for example, a strip of land

thirty miles wide on a straight line between New York and Washington, there are 7.35 square miles of emergency landing fields, as marked on the U. S. air navigation map, as against 550 square miles of available inland water landing places. In water landings there is considerably smaller chance of running into an unseen obstacle; further, water areas are the most visible objects on the ground surface; and finally, the water in practically every case is public or state property, and the pilot has no reason to avoid a landing. The New York-to-Washington route is mentioned here only as an example of such a route. There are many more favorable ones such as from New York to Albany, and thence to Montreal and Quebec, all above inland water.

It may seem unnecessary to place such importance on the question of emergency landing. An optimist may state that the question itself must cease to exist and the planes must always reach their destination. This appears correct in the case of the air liner, but smaller craft will get practical safety from this possibility even if it is only seldom used. Every railroad train is equipped with emergency brakes, and while they are rarely employed, they add materially to the safety of rail travel.

In the field of medium and huge air liners the possibilities of the amphibion are different but also important. For purely overland routes the landplane will remain the proper equipment because, for obvious reasons, it may have somewhat more lifting capacity and be less expensive. However, for mixed routes where water areas are to be traversed, the amphibion offers unquestionable advantages from the standpoint of safety. It is a proved fact that seaplanes afford considerably better protection to their occupants in case of landing on the water than do landplanes. A large number of fatalities have resulted from landplanes being forced down on water. It is quite different with the seaplane. A remarkably high percentage of seaplanes have survived after many days of buffeting in rough water of both oceans. Another distinct advantage which they possess is in landing in a harbor. The amphibion seems to be, in many cases, the proper equipment even over an all-water route. Its advantages, as compared with the seaplane, are much easier maintenance and the substantial economy of time which results from its ability to taxi straight out of water instead of requiring supporting platforms and dollies to pull it to land from the water. In rough weather or in winter this is a difficult procedure, and its total elimination, as well as the ability to land in an airport whenever desired, more than compensates for the slight decrease in speed and lifting capacity caused by the landing gear.

Amphibion Planes for Transoceanic Travel via Seadromes

Another important field limited to large multi-motored amphibion planes is transoceanic travel via seadromes, as proposed and developed by Mr. Armstrong. As a variation of the scheme, it may be supposed that the passenger-carrying amphibion will not land on every seadrome. The fastest air liners may even traverse the ocean without stop, but they will fly alongside the line of seadromes, will use them in case of emergency, will remain all the time in radio communication with the seadromes, and will be refueled in the air by special gasoline-carrying planes which will be stationed at each seadrome. The brilliant achievements of several duration fliers which culminated with the excellent record of the crew of the St. Louis *Robin* that spent half a month in the air, proves the feasability of such methods.

The great route connecting the United States with Latin America, because of geographic characteristics, is also best served by large amphibions. In this case also it seems that refueling in the air may be of value in certain places to reduce the time necessary for landing, custom formalities in the different countries traversed, etc.

Fig. 3 S-38 Amphibion in Full Flight

This brief outline covers only a few of the possible uses of the amphibion, for there are a considerable number of additional cases where it might render excellent service. The author would not be understood as underrating the value of the two other types, for it is also too early to judge the relative importance of the various types, and it even seems unnecessary. In the great ocean of the air there would seem to be plenty of room for all of them, as well as probably for new ones yet to come.

Thomas Newcomen, the inventor of the atmospheric steam engine, was born and lived in Dartmouth and his death took place on August 5, 1729, two hundred years ago. The West Country, the land of Raleigh, Hawkins, and Drake, can boast of men famous in all walks of life, in science and engineering, as well as in literature and art, and from Devonshire, Somerset, and Cornwall have come Sir Humphry Davy, Thomas Young, Richard Trevithick, Froude, and many others, among whom, however, is not one whose work has had a greater influence upon the progress of civilization than has that of Thomas Newcomen. His fame is often overshadowed by the great reputation of Watt; the significance of his invention is seldom fully appreciated by engineers themselves.—Eng.-Capt. Edgar C. Smith in *Engineering*, July 19, 1929, p. 84.

A Thermodynamic Analysis of the Steady Flow of Fluids

By C. HAROLD BERRY,[1] CAMBRIDGE, MASS.

THIS paper is an outgrowth of a lecture delivered by the author at the Summer School for Engineering Teachers conducted by the S.P.E.E. at Purdue University during July, 1929.

There is nothing new in the discussion it presents, unless it be the conciseness and generality of the treatment. The author has had the material in his notes in substantially its present form for more than ten years, and during the same period it has appeared in more or less complete form in several textbooks. The only excuse for publishing the material here is that it provides a powerful tool that is less familiar to engineers than it should be.

CLASSIC thermodynamics develops an analysis of the heat-power process in terms of cycles or "constant-something" changes of state. The cycle is satisfactory for the plant as a whole, although it often appears somewhat arbitrary—witness the difficulty of establishing a parallel between a cyclic process conducted in a closed cylinder and the actual working of a steam-turbine plant. In the case of the "open" cycles, the difficulty is even greater. How, for example, can we set up a cycle that really represents the chain of events in a vapor-compression refrigeration plant using an expansion valve?

In a real sense the internal-combustion engine is a complete plant in itself, for which a cycle analysis is wholly satisfactory. This discussion applies particularly to the steam power plant and its elements.

When we attack the study of individual pieces of equipment, cycles are of no use, because there is not a single thing in a power plant that *by itself* causes the working substance to execute a cycle. Each machine receives its steam or other fluid in one state and discharges it in another. By no stretch of the imagination can this be correlated with any cycle whatever.

Moreover the simple ideal "constant-something" changes of state will not help either, for rarely is anything constant. For example, consider a superheater. Steam enters at, say, 250 lb. per sq. in., and leaves at 200 lb. per sq. in. Pressure, temperature, specific volume, entropy, total heat, internal energy, velocity, are all different. By what process shall we idealize what happens? The conventional constant-pressure process is not satisfying where such large pressure changes are observed in current practice. We calculate the heat transfer as the change in value of the total heat of the steam, because this is true for a constant-pressure process, but if the pressure is not constant, is this still true? And why?

Plainly, some analysis is needed that is closer to the real thing.

Flow the Common Characteristic

The one thing that is common to all pieces of power-plant equipment is that through each one there is a more or less continuous flow of one or more fluids. An obvious step, then, is to see what can be done by way of setting up an ideal type of flow and developing relations among the observable quantities. To this ideal type of flow we give the name "steady flow," and in the following paragraphs its definition is established and its correspondence with real flow conditions discussed.

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Steady Flow Defined

It is proposed to define steady flow as the ideal counterpart of real flow, and in doing this it is particularly desirable to avoid imposing needless restrictions. The fewer the simplifying assumptions, the more generally useful will the conclusions be. The definition naturally divides itself into seven items, which will be stated and discussed by number.

1 A stream of fluid flows through any apparatus whatever. The apparatus may comprise anything from a straight length of pipe to a complete power plant. The fluid flowing may be any whatever.

This is no restriction.

2 During its passage through the apparatus, the fluid may execute only thermodynamic changes of state.

This is an obvious restriction necessary to permit a thermodynamic analysis of the process. It is of a piece with the similar restriction in the case of a fixed mass of material confined in a cylinder. The only processes under consideration are transfers of work and heat and the accompanying changes in the values of the quantities determining the thermodynamic state of a body and of functions of those quantities.

3 At entrance to the apparatus the quantities determining the thermodynamic state of any body of the flowing fluid do not vary with respect to time.

4 Similarly, at exit from the apparatus there may be no variation in any quantity.

Items 3 and 4 simply require that instruments responsive to pressure, temperature, density or specific volume, velocity, elevation, etc., must show no variations in the quantities observed. This seems a wholly sensible restriction, for if we do not know where our fluid starts from and finally arrives, we cannot study its change of state. We can measure the values of the several quantities only if they are free from significant fluctuations. For instance, if the pressure gage at entrance shows variations between 50 and 150 lb. per sq. in., it is obvious that we cannot properly speak of *the* pressure of the fluid at that point. So also with all other quantities. Variations from moment to moment must be absent.

For many real pieces of apparatus, these restrictions present no difficulty.

Perhaps it should be emphasized that the definition requires only that each quantity have a steady value at entrance and at exit. The values at the two points are not required to be the same; indeed, in general, several, and often every one, of the quantities involved will have different values at the two points.

Suppose the instruments, or one or more of them, do show variations—what is to be done? Either of three things:

a It must be agreed that the variations are negligibly small, and that some sort of "average" value may be taken. It should be recognized that the establishment of a single numerical value to represent the "average" of a fluctuating quantity rests at best on a rather insecure foundation. Only the impossibility of eliminating the fluctuations can justify using so doubtful an "average" value.

b It must be agreed that the variations are satisfactorily slow, and that simultaneous readings of everything at entrance and exit will fairly represent operating conditions; or

c Another point must be selected as the entrance to or exit from the apparatus. For example, it may be necessary to include a receiver as though it were an integral part of a reciprocating engine or compressor.

5 Entrance and exit must each be a definite cross-section of the fluid stream at which all observations must be made.

Obviously, we must make all observations for entrance and all for exit at the respective points. These sections need not be plane,

but must be definite. It is not permissible to measure pressure at one point and velocity at a remote point, unless of course it is certain that there is zero change between those points.

What shall be done if a quantity varies across the cross-section of the stream, as, for example, the velocity of water in a pipe or the temperature of a hot fluid cooling by heat transfer? Here lies a real difficulty. The best that can be done is to find an average value, and this is assumed to be possible and acceptable. It may be some sort of weighted average, but it is a representative value. All of this is plain common sense and gives rise to little difficulty in real cases.

6 The mass flow of fluid at entrance and at exit must be equal. There may be no variable storage of material within the apparatus.

The rate of flow is assumed to be measurable. What about a reciprocating engine or compressor, which takes in a mass of material, holds it for a portion of a stroke, and discharges it? This is not steady flow, and accordingly may be dismissed as being outside the field under discussion. On the other hand, if there be included with the engine or compressor sufficient piping or receiver volume at both entrance and exit, the fluctuations can be reduced and the process will closely approach steady flow. The general correspondence between test results and computed values seems to justify this treatment of such cases.

Putting the matter in other words, if there be included enough piping or receiver volume to secure dependable observations of the state of the streaming fluid at entrance and at exit, the variable storage of material within the apparatus may safely be neglected because of its high-frequency periodicity.

7 There may be no change in the thermodynamic state of the structure of the apparatus itself. That is, any transfer of heat or work to or from the apparatus must be transferred to or from the flowing fluid. There may be no variable storage of energy within the apparatus.

The apparatus must have no springs that are gradually wound up or released, no masses of metal that are slowly heated or cooled. In other words, before measurements are taken, flow must have been proceeding for a sufficient time to insure thoroughly steady conditions.

This seems to present difficulties only in the case of reciprocating machines, with respect to heat transfers between the steam or other fluid and the cylinder walls. But, as in the case of item 6, this is a high-frequency periodic process, and it seems justifiable to assume that by and large it produces no very significant effect beyond the loss of available work, which is accounted for otherwise.

This definition of steady flow sets up an ideal type of flow that approximates real flow conditions in virtually all engineering apparatus through which continuous flow takes place. The approximation is probably as close as that involved in setting up an ideal cycle for a power plant, and perhaps it is as close as the computation of stresses in structures on the assumption of rigid structural members.

THE CHANGE OF STATE OF THE FLUID IN STEADY FLOW

The definition makes it possible to establish completely the thermodynamic state of each particle of the flowing fluid at entrance to and exit from the apparatus in question. The absence of time variation of the quantities determining the state of the fluid simply means that each particle of the material, as it passes the entrance (or exit) section, is in precisely the same state as every other particle preceding (or following) it was (or will be) in when it passed (or shall pass) that point. Accordingly, using specific (per pound) extensities, it is proper to speak of the volume, entropy, internal energy, kinetic energy, potential energy, and total heat per pound of fluid at entrance and at exit.

Stating the entrance and exit states of the fluid defines the change of state executed between those points. Nothing is said about the *path* of the change. Usually it is unknown for a *real* case, and fortunately it is of no special interest, as will be shown later. In an assumed *ideal* steady flow, the nature of the path is usually established by assumption or definition.

Let the reader be reminded that a change of state of a body is completely defined by giving the initial and final states of equilibrium. The nature of the path is an independent matter. For example, Fig. 1 indicates two states, 1 and 2 (the coordinate variables may be any whatever). Three paths are shown, and there might be a million of them, but there is only one change of state, *the* change of state, 1, 2. The initial and final states must be states of equilibrium, for no other states of a body are capable of numerical description.

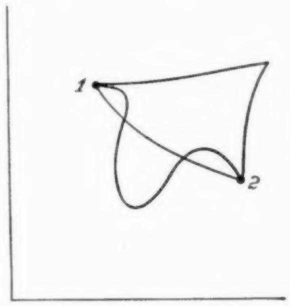

FIG. 1

THE EQUATION OF CONTINUITY

The first basic equation characterizing steady flow arises directly from item 6 of the definition. It simply asserts that the rates of mass flow through entrance and exit are equal.

$$\text{Mass flow} = \text{Area} \times \text{Velocity} \times \text{Density}$$

In symbols, with V = velocity, ft. per sec.
A = area, sq. ft.
d = density, lb. per cu. ft.
v = $1/d$ = specific volume, cu. ft. per lb.
Subscript 1 = entrance
Subscript 2 = exit,

the equation becomes

$$A_1V_1d_1 = A_2V_2d_2 \qquad [1]$$

or

$$\frac{A_1V_1}{v_1} = \frac{A_2V_2}{v_2} \qquad [2]$$

This simple and obvious relation seems hardly to merit its long name.

THE ENERGY EQUATION FOR STEADY FLOW

The general energy equation applies to any change of state of a body, reversible or irreversible, real or ideal; in particular it applies to any change of state executed in steady flow. It asserts that the heat transferred to unit mass of the fluid plus the work transferred to (done upon) unit mass of the fluid is equal to the concurrent increase in value of the energy of unit mass of the fluid, which is the sum of the increases in internal energy, kinetic energy, and potential energy. Expressing these quantities in British thermal units per pound, the equation becomes

$$q_{to,\,12} + w_{to,\,12} = u_2 - u_1 + \frac{V_2^2 - V_1^2}{50{,}000} + \frac{z_2 - z_1}{778} \qquad [3]$$

where[2] $q_{to,\,12}$ = heat transferred to unit mass of the flowing fluid between entrance and exit, B per lb.
$w_{to,\,12}$ = work transferred to (done upon) unit mass of the flowing fluid between entrance and exit (see discussion below), B per lb.
u = specific internal energy of the fluid, B per lb.
V = velocity, ft. per sec.

[2] As will be noted, the author uses the symbol "B" for the British thermal unit, in accord with the action recently taken by the A.S.M.E. Power Test Codes Committee.

z = elevation above datum, ft.
Subscript 1 = entrance
Subscript 2 = exit
50,000 = approximately 778 × $2g$, giving kinetic energy in B per lb.
778 = Joule's equivalent, giving potential energy in B per lb.

All values in the right-hand member are determined from observations at the entrance and exit sections of the flowing stream. The left-hand terms require further discussion.

The Heat Transfer. The term $q_{to,12}$ is the heat transferred to the apparatus or to the flowing fluid direct, between entrance and exit, per unit mass of fluid flowing. It is the net aggregate of positive and negative transfers of heat to the ensemble. It is the ratio of the rate of heat transfer *to*, in B per unit time, to the rate of mass flow, in lb. per unit time. It is determined from the conditions of the problem, or is the unknown for which solution is to be made. But in any case it is real heat transfer, recognizable from outside the apparatus. As will be shown later, so-called internal heating of the fluid, due to friction, is no part of this term. This is real heat transfer between the apparatus and external bodies, hot or cold.

The Work Transfer. The term $w_{to,12}$ is similarly the net aggregate of work transferred to the apparatus or to the flowing fluid direct, between entrance and exit, per unit mass of fluid flowing, measured in B per lb.

Now the one thing that distinguishes a change of state in steady flow from a change of state of a fixed mass confined in a cylinder is that in steady flow there are two elements of work transfer that are always necessarily present. These, together with the work otherwise transferred, comprise three work terms, two which can be formulated in general for any case of steady flow, and one which must be found specially in each case.

The Work Transfer at Entrance. Each particle of the flowing fluid, as it enters the apparatus, is pushed across the entrance cross-section of the stream by forces external to itself and to the apparatus. These forces advance and develop positive work upon the particle: the particle receives the work

$$+\frac{144}{778}p_1v_1\Delta m \quad \text{B} \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

where p_1 is the pressure (lb. per sq. in. abs.) prevailing at entrance, v_1 is the specific volume of the fluid (cu. ft. per lb.) at entrance, and Δm is the mass of the particle (lb.). Since each particle, on passing this entrance section, is subject to the same pressure and has the same specific volume, it follows that, per pound of fluid, the entrance work transferred *to* the fluid is

$$+\frac{144}{778}p_1v_1 \quad \text{B per lb.} \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

The Work Transfer at Exit. Each particle of the fluid, as it leaves the apparatus, is pushed across the exit cross-section of the stream against resisting forces external to itself and to the apparatus. These forces retreat, and develop negative work upon the particle: the particle receives the work

$$-\frac{144}{778}p_2v_2\Delta m \quad \text{B} \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

As before, it follows that, per pound of fluid, the exit work transferred *to* the fluid is

$$-\frac{144}{778}p_2v_2 \quad \text{B per lb.} \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

Work Transfers Within the Apparatus. The fluid, in flowing through the apparatus, may receive further quantities of work *to*, positive, zero, or negative. Since, by the definition of steady flow, there are no work transfers to or from the structure of the apparatus itself, the work transferred to the fluid is simply the work delivered to the apparatus by the action of outside forces. For simplicity of notation we shall designate this portion of the work transfer by the same symbol that has been used for the work transfer in the energy equation: namely, $w_{to,12}$.

The Aggregate Work Transfer. Adding the three elements, we find that, because of its participation in the steady-flow process, each pound of fluid receives the work

$$+\ w_{to,12} + \frac{144}{778}p_1v_1 - \frac{144}{778}p_2v_2 \ldots\ldots\ldots\ldots [8]$$

This value is to be substituted in Equation [3], which asserts that for any body executing any change of state, the sum of the aggregate net transfers of heat *to* and work *to* equals the concurrent gain in the total energy of the body.

$$q_{to,12} + w_{to,12} + \frac{144}{778}p_1v_1 - \frac{144}{778}p_2v_2 = u_2 - u_1 + \frac{V_2^2 - V_1^2}{50{,}000} + \frac{z_2 - z_1}{778} \ldots [9]$$

The last two terms in the left-hand member of Equation [9] are determined from observations at entrance and exit. Let them be transposed to the right-hand member, so as to bring together all terms so determined.

$$q_{to,12} + w_{to,12} = u_2 - u_1 + \frac{144}{778}p_2v_2 - \frac{144}{778}p_1v_1 + \frac{V_2^2 - V_1^2}{50{,}000} + \frac{z_2 - z_1}{778} \ldots [10]$$

This is the equation for steady flow in its most general form. In one special case, to be mentioned below, it is used in this form, but in a great many cases it chances that the first four terms in the right-hand member always appear, and accordingly it is convenient to simplify the equation by combining the internal energy with the flow work and giving the resulting quantity a name and symbol.

$$u + \frac{144}{778}pv = h \ldots\ldots\ldots\ldots\ldots\ldots [11]$$

This quantity is called the *total heat*, the *heat content*, or the *enthalpy* of the body. These are unfortunate choices of words, for the quantity has no more to do with heat transfers than with work transfers. It is not something contained in the body. It is simply a quantity established by arbitrary definition, whose values are in one-to-one correspondence with the states of the body. On the whole, the name *enthalpy* is the best of the three, because it does not suggest false meanings to an English-speaking engineer; accordingly, with apologies to the reader, the author will use this name in further discussion.

Let it be noted in passing that the specific enthalpy of steam or other vapors is to be found from suitable tables. For an ideal gas, however, it is easily computed from the simple formulation

$$h = c_pT + \text{constant} \ldots\ldots\ldots\ldots\ldots [12]$$

That is, the change in specific enthalpy of an ideal gas for a given change of state is computed precisely as is the change in specific internal energy, but using c_p instead of c_v.

$$h_2 - h_1 = c_p(t_2 - t_1) \ldots\ldots\ldots\ldots\ldots [13]$$

For liquids that are slightly compressible, like water, the same relation is often assumed to be exact. It is not. The enthalpy of liquid water does change with pressure at constant temperature, but for moderate pressure changes the effect is small. For engineering work the approximation is satisfactory, save for the higher pressures now becoming more common in power-plant work, for which a more exact determination of h is necessary. This is outside the scope of this paper.

The Steady-Flow Equation in Final Form. Substituting the newly defined enthalpy in Equation [10] gives

$$q_{to,\,12} + w_{to,\,12} = h_2 - h_1 + \frac{V_2^2 - V_1^2}{50{,}000} + \frac{z_2 - z_1}{778} \ldots [14]$$

This is the Steady-Flow Equation, perhaps the most widely useful equation in technical thermodynamics. It applies to any case of steady flow, real or imaginary, turbulent or orderly, simple or complex. There is no restriction on the nature of the change of state executed by the flowing fluid within the apparatus: all restrictions are confined to the entrance and exit conditions, and they must simply be observable and steady.

Work Done Against Friction

One general topic remains to be discussed. Whenever real fluids flow through actual apparatus, work is done against friction. Where does this appear in Equation [10] or [14]?

Work done against friction is dissipated as heat developed at the rubbing point. In the case of steady flow, this heat may go in either of two directions:

1 It may pass outward, wholly or in part. In that case it appears in the q-term, since if the heat transfer *to* or *from* the apparatus were measured, frictional heat could not be distinguished from any other heat.

2 It may pass inward, wholly or in part. In that case it appears, or rather lies concealed, in the right-hand member of the equation, since the transfer of frictional heat to the fluid, just like the transfer of heat from outside hot bodies, adds to the total energy of the fluid.

In the one and only application of this equation of steady flow to a process whose thermal aspect is negligible, the q- and u-terms are omitted, and in this one case work done against friction must be included as a separate term. This case, as will appear, is usually considered outside the realm of thermodynamics.

In the traditional thermodynamic field, then, one need never worry about work done against friction. It is fully covered by the several terms of the Steady-Flow Equation. The w-term is the actual work delivered *to* or *from* the apparatus. It is real external work that could in any case be produced by the falling of a weight, or, in the opposite sense, could lift a weight, through the action of a suitable mechanism. It exists through the action of real, identifiable external forces.

Applications to Cases

In the use of Equation [14], each of its terms must be found from the conditions prevailing. Fortunately, in most cases some of the terms vanish, yielding simple equations for such cases. It is helpful, however, to recognize such as special cases of the general problem. If the special form of equation is forgotten, or if the circumstances are unusual, so that the propriety of using the special form is open to question, the general form [10] or [14] may be used with the assurance that it always applies for any steady flow of any fluid.

The Flow of Water Through a Pipe or Channel. The flow of water through a pipe or channel is a process whose thermal aspect is usually negligible. The heat transfer is taken as zero. Further, there is no appreciable change in the thermodynamic state of the water, wherefore the internal energy of the water is assumed to be unchanged: $(u_2 - u_1)$ is taken to be zero. These assumptions are not strictly true, but are of a piece with the common statement that water is incompressible. The departure from precise fact is trivial except for processes involving large pressure changes.

Using the form of Equation [10] instead of [14]—they are wholly interchangeable—and taking all quantities in ft-lb. per lb., the equation becomes

$$w_{to,\,12} = 144\, p_2v_2 - 144\, p_1v_1 + \frac{V_2^2 - V_1^2}{2g} + z_2 - z_1 \ldots [15]$$

Taking pressures in lb. per sq. ft., and remembering that specific volume is the reciprocal of density, gives

$$w_{to,\,12} = \left[\frac{P_2}{d_2} + \frac{V_2^2}{2g} + z_2\right] - \left[\frac{P_1}{d_1} + \frac{V_1^2}{2g} + z_1\right] \ldots [16]$$

This is the equation frequently known as Bernoulli's Theorem. Since the q- and u-terms are absent, the w-term must include work developed against the resistance of internal frictional forces. Work dissipated through friction is always a negative quantity of work *to* the fluid. Friction opposes flow. The work term of Equation [16] is accordingly the net sum of three items: (1) Positive work *to* in the case of a pump; (2) negative work *to* in the case of a water wheel; (3) negative work *to* through friction.

Since the application of this equation is outside the traditional field of thermodynamics, it will be discussed no further here. It is introduced simply to indicate the generality of the basic equation of steady flow.

Thermodynamic Applications. The application of Equation [14] to the flow of fluids executing a significant change of thermodynamic state may involve all the terms of the equation, and in particular the h-terms always remain significant. On the other hand, the difference between the two z-terms is usually very small. For example, consider a flow in which the change in level is 100 ft. The change in specific potential energy is then 100/-778 = 0.13 B per lb., a negligible value in most cases. Moreover a change of elevation of 100 ft. is far greater than is usually encountered. Accordingly in further discussion the z-terms will be dropped, but the reader should bear in mind that if a problem arises in which there is a large change of elevation or in which high precision is needed and attainable, the z-terms should be retained.

Equation [14] is now reduced to

$$q_{to,\,12} + w_{to,\,12} = h_2 - h_1 + \frac{V_2^2 - V_1^2}{50{,}000} \ldots\ldots [17]$$

The Ideal Engine. Velocity at entrance equals velocity at exit. Both are often tacitly assumed to be zero. In any event the difference between their squares is zero. Further, the machine is assumed by definition free from heat transfers. The q-term is zero. This leaves

$$w_{to,\,12} = h_2 - h_1 \ldots\ldots\ldots\ldots\ldots\ldots [18]$$

For convenience, it is common to reverse signs, substituting work *from* for work *to*, or

$$w_{from,\,12} = h_1 - h_2 \ldots\ldots\ldots\ldots\ldots\ldots [19]$$

The engine being ideal, it is assumed that the process is such that the work *from* is the maximum possible under adiabatic conditions; this implies the reversible adiabatic, or isentropic change of state. State 1 is defined by the values of appropriate variables, usually pressure and temperature or quality. State

2 is defined by the value of one variable, usually pressure, together with the value of the specific entropy found for state 1.

Be it noted that Equation [19] gives the work developed by an engine, *not* because it causes anything to execute a cycle, but because through it there is steady flow. In no steam engine *by itself* is there a cycle completed.

The Ideal Compressor. The ideal reciprocating compressor is not simply the ideal engine reversed. The basic assumptions are different, in that it is assumed that heat is abstracted so as to maintain the temperature constant. If the temperatures at 1 and 2 are the same, then, according to Equation [13], the change in value of h is zero. Accordingly, Equation [17] reduces to

$$q_{to,\,12} + w_{to,12} = 0 \qquad [20]$$

This tells us almost exactly nothing about the performance of the compressor. The work term must be computed from other considerations.

In the case of the turbo-compressor, isentropic compression is commonly assumed, and then Equation [18] furnishes the means of computing the work done upon the gas.

The Ideal Pump. With particular reference to the boiler-feed pump, a special remark is in order. It might be thought that Equation [16], with due allowance for friction, might suffice, but it proves to be otherwise. In thermodynamic studies the thermal effects are not negligible, although they may be small. Recent discussions have centered around the increase in the enthalpy of water in passing through a high-pressure feed pump. Accordingly, the ideal pump must be treated as the reverse of the ideal engine, for which Equation [18] is appropriate. The assumptions that the process is adiabatic and that there is negligible change in kinetic energy seem acceptable.

The Real Engine or Turbine or Compressor or Pump. Reversing signs in Equation [17] gives

$$q_{from,\,12} + w_{from,\,12} = h_1 - h_2 + \frac{V_1^2 - V_2^2}{50{,}000} \qquad [21]$$

What of the velocities at entrance and exit, at throttle and exhaust, at suction and discharge? With steam velocities up to 20,000 ft. per min. at the throttle and 25,000 in the exhaust, the V-terms cannot summarily be neglected. Let the possibilities be examined. Suppose V_2 is 24,000 ft. per min. This is 400 ft. per sec., and $V_2^2/50{,}000$ becomes about 3 B per lb. V_1 cannot be zero, but it might be as low as $^1/_3$ of V_2, so that V_1^2 might be as low as $^1/_{10}$ of V_2^2. Accordingly, in the case of a real machine, the change in kinetic energy may be as great as 3 B per lb. It is not likely to be much greater; usually it will be smaller. It is customary to drop the term, assuming that the change in kinetic energy is zero, but it must be borne in mind that in precise work this is not allowable. In any real case the value is easily computed, so that its significance can be appraised. Dropping the V-terms leaves

$$q_{from,\,12} + w_{from,\,12} = h_1 - h_2 \qquad [22]$$

In the actual machine, the work developed is usually measured during a test. The heat developed is usually estimated. The initial enthalpy is found for the known initial state. The final enthalpy can then be computed. This, together with the observed terminal pressure, completely identifies the final state of the fluid flowing.

An alternative method of testing small steam turbines rests on Equation [22]. Small, inefficient turbines receiving superheated steam often show superheat in the exhaust steam. If this be the case, the actual state of the exhaust steam can be observed by pressure gage and thermometer. So also can the state of the steam at entrance. Thus both h_1 and h_2 can be found from simple observations without disturbing the operation of the machine. If the heat "lost by radiation" be estimated (or neglected), Equation [22] gives a ready means for computing the work developed per pound of steam, and hence the steam rate and efficiency of the turbine.

In applying Equation [22] it must be remembered that the q-term includes work done against friction and lost as heat. Bearing friction must be included with other external heat losses.

Heat Exchangers—Closed Type. Two or more distinct fluid streams flow through any device in which there is heat transfer between the distinct streams, through the agency of intermediate transfer surfaces. The steady-flow analysis is to be applied to each fluid stream separately.

The work transfer to or from the device is zero, and since frictional work is covered elsewhere, the w-term in the equation is zero. As in cases considered above, it is customary to assume no material change in kinetic energy. Equation [17] thus reduces to

$$q_{to,\,12} = h_2 - h_1 \qquad [23]$$

This equation may be written separately for each of the distinct fluid streams. For the apparatus as a whole, the q-terms may be added and equated to zero, or to some assumed or computed value of external heat loss from the apparatus, and thereby the familiar "heat-balance" equation is set up for the apparatus.

It should be noted that, for any heat exchanger, while the entrance and exit pressures must each be constant with respect to time, they need not be equal. Friction always opposes flow, so that the pressure is less at exit than at entrance. Frictional work is cared for by the equation; the pressure drop does not affect the result. For instance, consider the superheater mentioned in an earlier paragraph. It receives steam at pressure of 250 lb. and discharges it at 200 lb. How much heat does the steam receive? Plainly this is a case of steady flow, and Equation [23] asserts that the heat *to* equals the gain in the enthalpy of the steam. The value h_1 is found for the pressure and quality at entrance, and h_2 for the pressure and temperature at exit. That the two pressures are not the same does not affect the dependability of the result. The heat transferred to the steam equals the gain in enthalpy of the steam, not because the actual process approximates a constant-pressure change of state, but because it is an instance of steady flow.

Heat Exchangers—Open Type. It is an easy step from the closed heat exchanger, e.g., the surface condenser, or tubular heater, to the open type, e.g., the jet condenser, or open heater. One stream of fluid enters as cold water and leaves as hotter water. The other stream enters as steam and leaves as water. That the two exit streams are mixed does not appear to present any special difficulty, since they are mixed at constant pressure, and the enthalpy of such a mixture is simply the sum of the enthalpies of its components. If the materials were dissimilar, matters would not be so simple, e.g., if steam were mingled with liquid alcohol or sulphuric acid. Accordingly it is safe to say that in the case of open heat exchangers involving two streams of the same chemical substance, the same heat-balance equations apply. If the substances differ, so that the heat of dilution enters, additional terms must be introduced to cover the quantity of heat thus developed. Otherwise the method is substantially the same.

What about the injector and allied devices? This is an open type of heat exchanger, but it is more, since one stream transfers mechanical work to the other, so that the device acts as a pump. The steady-flow analysis is inadequate to cover this pumping action. If the equation be set up for an injector,

the final result will be the simple heat balance, precisely as though the injector were replaced by an open heater receiving like quantities of steam and water. The steady-flow equation yields no information concerning the final pressure of the water;[3] on the other hand, it can be applied to the several elements of the injector process—the steam nozzle, the flow of water into the mixing chamber, and out through the diffuser. The velocity of water leaving the mixing tube, however, is found by equating momenta, and not from energy considerations, because energy is not conserved.

Nozzles. In a nozzle, the process is fairly taken to be adiabatic. The q-term is zero. As for a simple pipe or heating device, the work transfer to the apparatus is zero. The w-term is zero. Thus Equation [17] reduces to

$$0 = h_2 - h_1 + \frac{V_2^2 - V_1^2}{50{,}000} \quad [24]$$

or, transposing,

$$\frac{V_2^2 - V_1^2}{50{,}000} = h_1 - h_2 \quad [25]$$

If the nozzle be ideal, the process is isentropic. States 1 and 2 are thus fully defined, and the values of h are found. The ideal final velocity is easily computed.

For a real nozzle, an efficiency or velocity coefficient based on experimental observations is applied to the ideal final velocity to secure the actual jet velocity. Then, using the actual velocities and the known initial enthalpy, Equation [25] gives a means of computing the final enthalpy of the steam and hence its actual final state, since the values of h and p fully define the state.

The same analysis may be applied to any portion of a well-formed nozzle, since flow is steady throughout. Thus can be found the velocity, quality, etc. at the nozzle throat or at other intermediate points.

For an ideal gas, Equation [13] gives the change in enthalpy in terms of temperature difference. For an isentropic nozzle flow, results are computed from the characteristic equation, $144pv = RT$, together with the isentropic equations

$$pv^k = \text{constant}$$
$$Tv^{k-1} = \text{constant}$$
$$\frac{T^{\frac{k}{k-1}}}{p} = \text{constant}$$

The final result is one or another of the complex equations for gas flow through nozzles.

Throttling. A pure throttling process differs from nozzle flow in that the final velocity is the same as the initial, the kinetic energy developed being dissipated as heat through friction. Hence Equation [17] or [24] reduces to

$$0 = h_2 - h_1 \quad [26]$$

The enthalpy is unchanged by throttling.

Throttling is *not* a constant-enthalpy process. Any "constant-something" process implies that the particular something remains constant throughout the process. The specific enthalpy of the fluid does not remain constant in throttling, although it does approach this condition in a fine-grained porous plug. But the porous plug, important in the research laboratory, is not found in engineering practice. Throttling usually implies an orifice whence issues a jet at high velocity and correspondingly reduced enthalpy, followed by a turbulence chamber in which the kinetic energy is dissipated as heat, restoring the enthalpy to the initial value.

[3] This is not strictly true. The enthalpy does vary with pressure, so that the final enthalpy, from the steady-flow equation, together with a precise measurement of temperature, would identify the state, and make it possible to determine the pressure. The final temperature of water leaving the injector would be slightly less than that found for an open heater, but the difference would ordinarily be so small as to be unmeasurable.

Throttling is an adiabatic process that delivers no useful work (it does deliver the net aggregate of work at entrance and work at exit). An isentropic is an adiabatic process that delivers the maximum work possible adiabatically. This concept of the region of adiabatic changes of state is useful. On the one hand is the completely harnessed adiabatic, the isentropic, that delivers the maximum work. On the other hand is free expansion into a vacuum—Joule's famous experiment—that delivers no work at all. This is the completely dissipative, constant-internal-energy, or isodynamic process. Between these limits lies the entire range of adiabatic changes of state, each developing a portion of the maximum work available, and dissipating the remainder as heat.

It is particularly desirable to discourage the term "constant-heat process" for throttling. It is bad in every way. Heat cannot be constant. It may flow in or out, *to* or *from* at a constant rate; but it cannot be constant. There is no meaning to the phrase "heat in the steam." Heat enters and leaves; it does not tarry. Heat is a mode of energy transfer; when it ceases to move, it ceases to exist.

The Steam-Turbine Bucket. Steam flow through the bucket passages is adiabatic, with or without change in pressure. The q-term in Equation [17] is zero. Work is developed in moving the bucket, i.e., work is done by the steam, transferred *from* it to the bucket. This work may be formulated in various ways, but for the present purpose the most convenient form is

$$-w_{to,\,12} = w_{from,\,12} = \frac{V_1^2 - V_2^2 - (V_{r1}^2 - V_{r2}^2)}{50{,}000} \quad [27]$$

where V_1 and V_2 are the absolute steam velocities at entrance and exit, and V_{r1} and V_{r2} are the velocities relative to the bucket at the respective points.

Substitution of the $q = 0$ and w_{to} from [27] in Equation [17] gives

$$-\frac{V_1^2 - V_2^2 - (V_{r1}^2 - V_{r2}^2)}{50{,}000} = h_2 - h_1 + \frac{V_2^2 - V_1^2}{50{,}000} \quad [28]$$

The absolute velocities appear on both sides of the equation with like signs, hence they cancel, leaving

$$\frac{V_{r1}^2 - V_{r2}^2}{50{,}000} = h_2 - h_1 \quad [29]$$

For an impulse bucket, V_{r1} is found from a vector triangle for entrance, and V_{r2} is usually expressed as V_{r1} multiplied by a bucket velocity factor. The value h_1 is known from the nozzle performance; h_2 can therefore be computed.

For a reaction bucket, V_{r1} is known from a vector triangle for entrance, and h_1 is known from computations for the preceding bucket row. The value h_2 is found for isentropic expansion and the bucket efficiency is introduced:

$$\frac{V_{r2}^2 - V_{r1}^2}{50{,}000} = (h_2 - h_1) \times \text{Efficiency} \quad [30]$$

The actual final velocity is then computed. Substitution of this value in Equation [29] makes it possible to find the actual value of the enthalpy of the steam leaving the bucket.

The Cycle of the Steam Plant. The study of plant cycles, assuming a fixed mass of fluid confined in a cylinder, deals

successively with processes of heating, evaporation, superheating, expansion, condensation, and compressing. For each of these processes the heat and work transfers are computed. There is an air of abstraction about this. For example, what about the work developed during evaporation? Where is this work found in the real plant? Surely not in the boiler, but in the engine, where evaporation is not executed. True, these difficulties are not serious; they are exaggerated here to draw attention to the contrast.

The steady-flow analysis of the plant cycle is carried out for the actual pieces of apparatus in the real plant, or at least for their ideal counterparts. It will be sufficient to outline

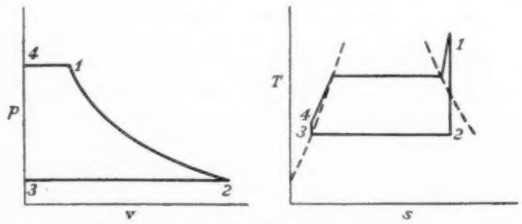

Fig. 2 The Simple Rankine Cycle

the steady-flow analysis of the ideal Rankine cycle (Fig. 2) of a simple steam plant. Equation numbers indicate the source of the equations in the foregoing discussion.

The engine, 1 to 2:

$$w_{from,\,12} = h_1 - h_2 \qquad [19]$$

The condenser, 2 to 3:

$$q_{from,\,23} = h_2 - h_3 \qquad [23]$$

The feed pump, 3 to 4:

$$w_{to,\,34} = h_4 - h_3 \qquad [18]$$

The boiler, superheater, etc., 4 to 1:

$$q_{to,\,41} = h_1 - h_4 \qquad [23]$$

The net work of the cycle equals the work *from* in the engine, minus the work *to* in the pump:

$$\text{Net work} = (h_1 - h_2) - (h_4 - h_3) \qquad [31]$$

The heat supplied is the heat *to* in the boiler, economizer, superheater, etc.:

$$\text{Heat supplied} = h_1 - h_4 \qquad [32]$$

The heat rejected is similarly the heat *from* in the condenser:

$$\text{Heat rejected} = h_2 - h_3 \qquad [33]$$

These results are of course identical with those obtained from the familiar cycle analysis. The steady-flow equation is merely another way of arriving at the same result, but it is a way that has more obvious connection with the real plant.

The Incomplete-Expansion Cycle. It may be illuminating to examine the conventional incomplete-expansion cycle (Fig. 3) that has long been used as a less exacting standard of comparison for the reciprocating steam engine.

One begins bravely enough by writing the steady-flow equation for the pump, from 4 to 5, and for the boiler, from 5 to 1. When the engine is attacked, things begin to tangle. State 2 is not the final state of the steam exhausted from the engine. Something is wrong. And then, what is to be done with the constant-volume process from 2 to 3? And the process from 3 to 4? This takes place in the condenser, of course, but it is by no means all that happens there. Exhaust steam entering the condenser has far higher quality than state 3 indicates.

The difficulty all lies in the constant-volume process, and it brings out a happy feature of the steady-flow equation. In what apparatus does this constant-volume process take place? Only in the mind of man. Nothing like it occurs in the real plant. It is not an idealization of what really happens; it

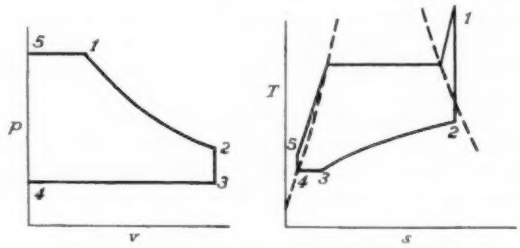

Fig. 3 The Incomplete-Expansion Cycle

is a conventional fiction, useful when properly understood, but having no relation to the study of a real plant. It simply fails to charge against the engine one of its losses, and in studying a real plant we dare neglect nothing. It is interesting to note that the steady-flow method of attack balks at a situation of this sort. Whenever it is out of touch with reality, it issues its own warning.

Conclusion

This discussion has been lengthy because it seemed desirable to do two things: to establish soundly the broad generality of the steady-flow equation, and to illustrate the scope of its usefulness by divers examples.

The author regards this equation as a highly powerful and valuable tool for the engineer, and believes that a more frequent use of it would tend to dispel something of the false air of mystery that seems to be associated with thermodynamics in the minds of some engineers. As a matter of fact, no branch of physics rests more closely on the ground of daily experience. The steady-flow equation should be useful because of its emphasis on this fact, through its almost unavoidable connection with real machines or their ideal counterparts, and its total neglect of the imaginary "constant-something" changes of state that are often not even approximated in real plants. Further, the steady-flow equation is easy to remember and easy to apply, and in many a complex situation it yields all the information the engineer needs.

If this discussion helps a little to extend the appreciation and use of this equation, perhaps its length and dryness may be justified, or at least excusable.

Is the critical point of water to be defined as that at which, according to the older but now untenable views, the specific volume of the vapor becomes equal to the specific volume of the liquid in equilibrium with it, or are we to regard as the critical point that at which the meniscus disappears when air-free water is heated to the appropriate temperature in a silica tube? Neither alternative is free from difficulty. Professor Callendar holds that steam does not exist when the temperature is 380.5 deg. cent. and the pressure 3650 lb. per sq. in. In these conditions, the water phase alone persists, and since no vapor can exist in the conditions stated, there is a difficulty in attributing to it either a specific volume or a latent heat. That water alone is present when the vapor and liquid lines of the border curve merge into each other, is supported by measurement of the total heat of water at this point, and further confirmation of this view seems to be afforded by chemical considerations.—*Engineering*, Sept. 6, 1929, p. 295.

Stresses in Turbine Pipe Bends

By A. M. Wahl,[1] J. W. Bowley,[2] and G. Back[3]

This paper records the results of a test in which actual strain measurements were made around the circumference of a pipe bend subject to a bending moment and internal pressure. The test results are compared with theoretical results obtained by a method developed in a previous paper by one of the authors[4] and show good agreement. The tests show that considerably higher stresses may occur than the ordinary bending theory would indicate. They also show that, because of the initial ellipticity of the cross-section of pipe bends produced during fabrication, comparatively high stresses may be set up by internal pressure. These facts may explain why pipe bends frequently undergo permanent set when placed in service. The work should be of practical value for pipe-bend designers.

In a previous paper[4] by one of the authors, entitled "Stresses and Reactions in Expansion Pipe Bends," methods were developed for the calculation of stresses and reactions in pipe bends using a more exact theory which took into account pipe cross-section distortion. Formulas were derived for

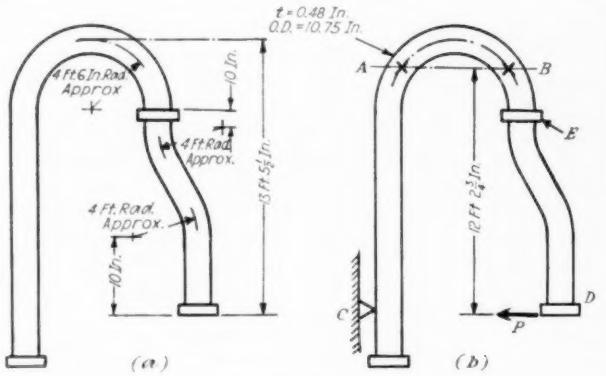

Fig. 1 Method of Testing Pipe

computing the maximum stress,[5] deflection, and distortion of the cross-section of pipe bends. Tests were made on small model bends which verified the deflection formulas given in the paper. It was not possible, however, to check up the stress distribution in these model bends by strain measurements because of their small size.

Method of Testing

To this end it was decided to make tests[6] on a large pipe bend, nominal diameter 10 in. extra strong, used as a steam inlet for a turbine. Its principal dimensions are shown in Fig. 1. A photograph of the pipe in position for testing is shown in Fig. 2.

A schematic diagram of the method of loading the bend is shown at *b*, Fig. 1. One end, *D*, of the pipe is loaded with a force *P*, the other side being supported by a knife-edge support *C*. Stresses were measured at sections *A* and *B*.

The method of loading is also shown in Fig. 2. The pipe is seen to be supported on rollers which allow free movement with little friction. Load is applied by tightening the nut *E* on the rod *F* loosely fastened to the flange at *D*. The line of action of the force in the rod passes through the fixed support *C*.

More details regarding the end *D* of the pipe are given in Fig. 3. Here the rollers supporting the ends of the pipe are clearly shown. It was first planned to measure the load by applying extensometers to the test piece *G* placed in series with the rod *F*. Two extensometers were placed on opposite sides of the

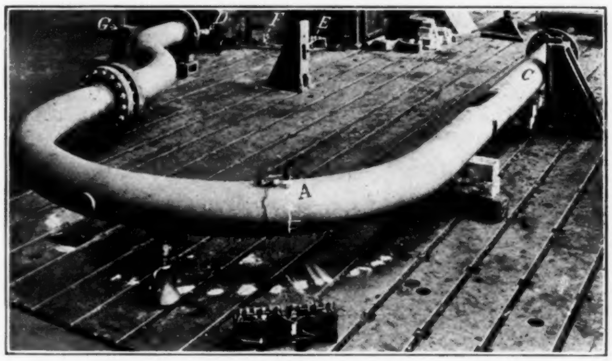

Fig. 2 Pipe-Bend Test Arrangement

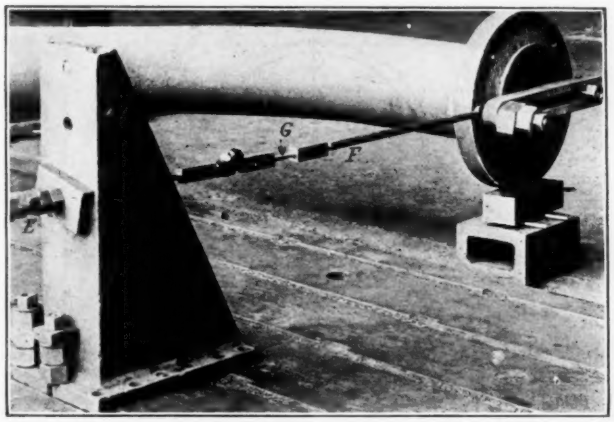

Fig. 3 Method of Applying Load to End of Bend

test piece, and the average extension taken as a basis in order to eliminate the effect of non-central application of load. Afterward this test piece was placed in a testing machine with the same two extensometers in position on opposite sides of the test pieces and a calibration curve obtained. However, because of the possibility of jarring during the loading, it was found more satisfactory to substitute for the test piece and extensometers a spring having a known constant. By tightening the nut *E*, load could be applied, causing the spring to stretch. The amount of extension of the spring gave a measure of the load. Values of load for a given deflection of the pipe determined in this

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[2] Turbine Engineering Dept., Westinghouse Electric & Manufacturing Co., South Philadelphia, Pa.

[3] Bureau of Standards, Washington, D. C. Formerly with Westinghouse Electric & Manufacturing Co., South Philadelphia, Pa.

[4] "Stresses and Reactions in Expansion Pipe Bends," by A. M. Wahl, Trans. A.S.M.E., Paper No. FSP-50-15, p. 241.

[5] After the paper was written the formulas for stress were independently given by Finniecome. See "The Flexibility of Plain Pipes," *The Engineer*, Sept., 1928; also *Metropolitan-Vickers Gazette*, May, 1928, p. 400.

[6] Recently, Professor Hovgaard has determined the transverse stress distribution in an indirect manner. See his paper in *Jl. Math. & Phys.*, vol. 7, no. 3, October, 1928.

manner were found to check within a few per cent with those obtained by the use of the special extensometers attached to the test pieces.

Deflections of the end of the pipe relative to the stationary block G, Fig. 2, were measured by means of a steel scale which projected from the block.

A close-up view of the special extensometer in position on the pipe wall is shown in Fig. 4. The electromagnet A, energized

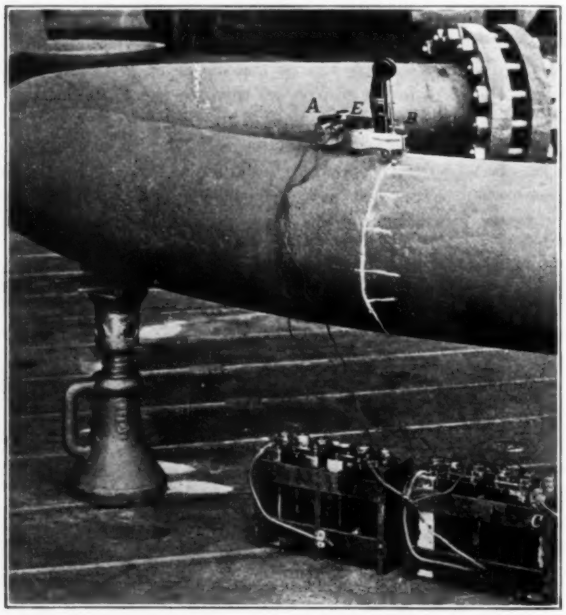

FIG. 4 EXTENSOMETER IN POSITION ON BEND

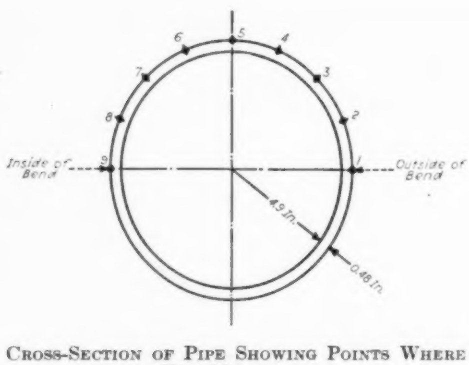

FIG. 5 CROSS-SECTION OF PIPE SHOWING POINTS WHERE STRESS WAS MEASURED

by the batteries C, has a projecting lug E which serves to hold the extensometer B firmly against the pipe wall. The extensometer may thus be quickly and easily attached at any desired position. By loading the pipe several times, with the extensometer in a different position each time, the stress distribution over the pipe cross-section could easily be obtained.

Extensometer readings were taken at nine different points equally spaced around the upper semicircumference of the pipe. A cross-section of the pipe, together with the points at which the stress was measured, is shown in Fig. 5. Chalk marks at section A (Fig. 2) also show positions at which the extensometer was applied. At each position the strains in both the longitudinal or axial direction and in the transverse or circumferential direction were measured. Readings were taken at these positions at loads corresponding to deflections of the end D of the pipe increasing by $^1/_2$-in. increments up to a maximum of $2^1/_2$ in., the maximum load at $2^1/_2$ in. deflection being found to be 1830 lb.

In determining the effect of internal pressure, the pipe was connected to a water pump by means of which a hydraulic pressure of 1000 lb. per sq. in. could be secured. As before, extensometers were placed at various points of the pipe cross-section as indicated by Fig. 5, and in this way the distribution of the stresses set up was determined. Readings of the extensometer were taken at increments of pressure of about 200 lb. per sq. in. up to a maximum of 1000 lb. per sq. in. In the internal-pressure test, the pipe was unbolted at the joint E (b, Fig. 1) and the portion ED rotated through 180 deg., so that the bend assumed the shape shown in Fig. 12.

STRESS DISTRIBUTION DUE TO EXTERNAL BENDING MOMENT AND COMPARISON WITH THEORY

The strains produced by the load on the pipe, loaded as in b, Fig. 1, as measured by extensometers at positions A and B were plotted against deflection of the end D. The longitudinal and transverse strains thus plotted for the various points 1–9 (Fig. 5) of the pipe wall at position A are shown in Figs. 6 and 7, respectively. The corresponding strains for position B are shown in Figs. 8 and 9.

An examination of these curves shows that the points in most cases lie very nearly on a straight line. In working up the results, straight lines were drawn which would most nearly pass through the plotted points. Values of strain indicated by these straight lines were taken as the true ones. It is believed that the measured strains determined in this way are accurate to within 5 per cent of the maximum strain, since the deviation of the plotted points from the straight line was never greater than about 5 per cent of this maximum strain.

In the case of the transverse stresses, which are bending stresses induced by flattening of the cross-section, the condition of bending of thin strips obtains,[7] and lateral contraction is practically prevented. Consequently the presence of these transverse bending stresses does not appreciably affect the strain in the longitudinal direction.

In determining the stresses from the measured strains a modulus of elasticity $E = 29 \times 10^6$ and Poisson's ratio $1/m = 0.3$ were assumed. The longitudinal stress is then given by the longitudinal unit strain multiplied by 29×10^6.

To determine the transverse stress at any point, Equation [10a], p. 12, "Applied Elasticity," was used. This equation is:

$$S_t = \frac{E}{1 - \frac{1}{m^2}} \left[e_t + \frac{1}{m} e_l \right] \ldots\ldots\ldots\ldots\ldots [1]$$

[7] See "Applied Elasticity," by Timoshenko and Lessells, p. 52, for more details regarding bending of thin strips.

TABLE 1 STRESS DISTRIBUTION AS FOUND BY STRAIN MEASUREMENTS AT 1830 LB. LOAD ON BEND

		Point of pipe circumference, Fig. 5								
		1	2	3	4	5	6	7	8	9
Longitudinal stress S_l	Position A	4,700	5,900	6,000	5,200	800	−5,000	−7,200	−7,000	−6,700
	Position B	5,300	6,200	7,100	5,800	1,500	−4,600	−8,300	−8,300	−7,500
Transverse stress S_t	Position A	−8,600	−5,900	400	6,700	8,600	5,100	−1,100	−8,300	−9,900
	Position B	−9,800	−6,800	−1,400	7,300	9,100	+7,100	−400	−9,000	−11,400
Equivalent stress $S_l - S_t$	Position A	13,300	11,800	5,600	−1,500	−7,800	−10,100	−6,100	+1,300	3,200
	Position B	15,100	13,000	8,500	−1,500	−7,600	−11,700	−7,900	700	3,900

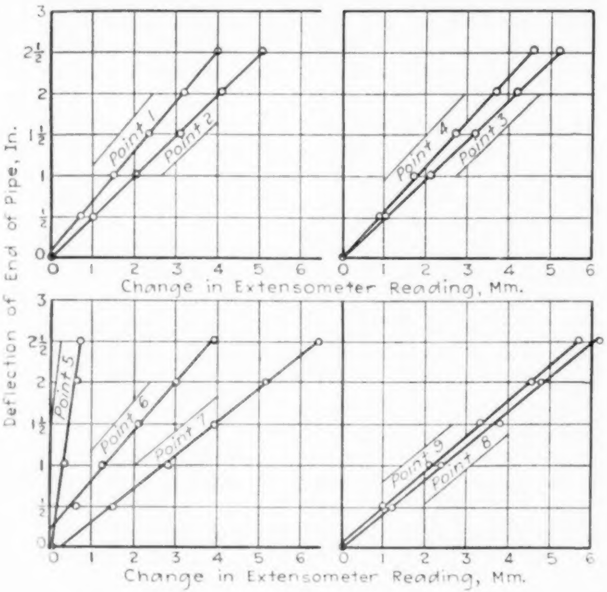

Fig. 6 Longitudinal Strains, Position A
(1 mm. extensometer reading = 0.0008 mm. strain; gage length = 2 cm.; $2^1/_2$ in. deflection = 1830 lb. load on bend.)

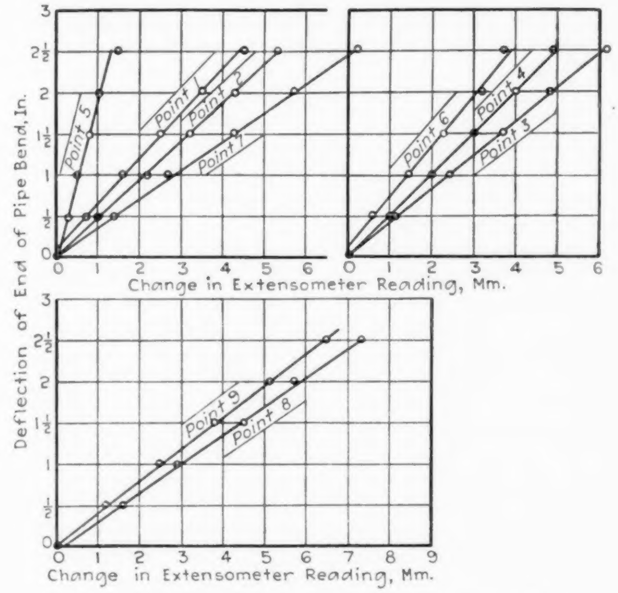

Fig. 8 Longitudinal Strains, Position B
(1 mm. extensometer reading = 0.0008 mm. strain; gage length = 2 cm.; $2^1/_2$ in. deflection = 1830 lb. load on bend.)

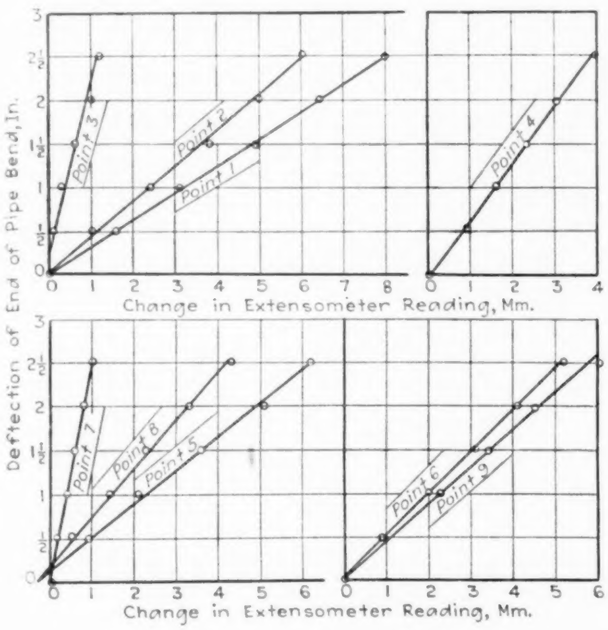

Fig. 7 Transverse Strains, Position A
(1 mm. extensometer reading = 0.0008 mm. strain; gage length = 2 cm.; $2^1/_2$ in. deflection = 1830 lb. load on bend.)

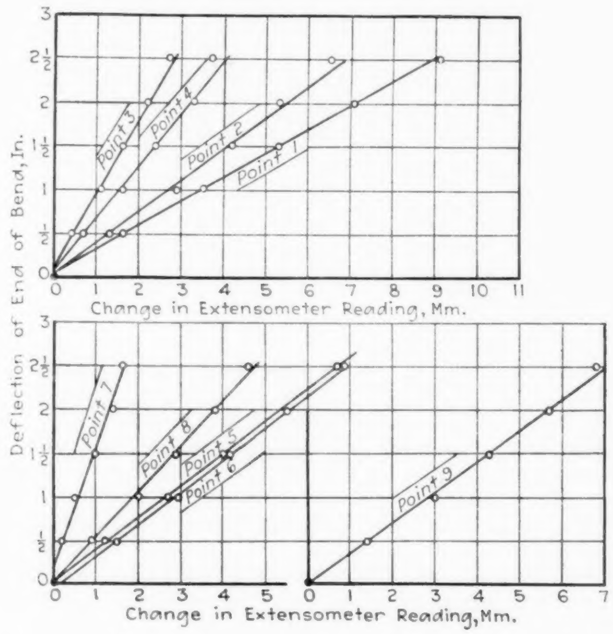

Fig. 9 Transverse Strains, Position B
(1 mm. extensometer reading = 0.0008 mm. strain; gage length = 2 cm.; $2^1/_2$ in. deflection = 1830 lb. load on bend.)

in which

$\frac{1}{m}$ = Poisson's ratio
S_t = transverse stress
e_t = measured transverse unit strain
e_l = measured longitudinal unit strain.

This is a fundamental equation for two-dimensional-stress problems.

The numerical values of stress thus obtained for both transverse and longitudinal stress at a load of 1830 lb. on the bend corresponding to $2^1/_2$ in. deflection of the end for both position A and position B (Fig. 1) at points 1–9 (Fig. 5) on the circumference of the cross-section are given in Table 1.

According to the so-called maximum-shear theory for combined stress, the "equivalent stress" or direct stress equivalent to the combined stress is equal to the algebraic difference between the largest and smallest principal stresses. Since at the outside of the bend there is a longitudinal tensile stress combined with a transverse compressive stress, it is necessary to take the *sum* of the absolute values of these stresses to get the true equivalent stress. Therefore, in Table 1 rows for "equivalent stress" have

been added, the stresses there given being equal to the algebraic differences between the longitudinal and transverse stresses ($S_l - S_t$).

It should be noted that at points where the stresses S_t and S_l have the same sign the *true* "equivalent stress," that is, the greatest equivalent stress at any point, will not be equal to their difference but to the larger stress, since the third principal stress is zero. However, the *maximum* equivalent stress in the pipe bend at the section considered will be equal to the maximum absolute value of the algebraic difference $S_t - S_l$.

The stress distribution over the cross-section at 1830 lb. load was also computed theoretically, using Equations [9] and [10] of the aforementioned paper.[4] In making these computations the actual dimensions given in Fig. 1 were used. The value of the mean outside diameter was measured with a tape at positions A and B (Fig. 1) and found to be very nearly the same at both. The thickness of pipe wall at A was determined by drilling two $^1/_2$-in. holes in the pipe wall at positions 90 deg. apart. In making the computations, the thickness at B was assumed to be the same as that found at A, namely, 0.48 in.

The value of the mean radius of pipe wall was assumed to be $r = 5.14$ in., which was the value found at A. Since the thickness at B was not accurately known, and since the mean outside diameter of the pipe cross-section at B was within 0.6 per cent of that at A, this value of r was also assumed for position B.

Equations [9] and [10] for computing longitudinal and transverse stress are:

$$S = \frac{My}{KI}\left(1 - \frac{6}{5 + 6\lambda^2}\frac{y^2}{r^2}\right)$$

$$S_t = \frac{Mr}{I}\left(\frac{18\lambda\left(1 - \frac{2y^2}{r^2}\right)}{1 + 12\lambda^2}\right)$$

where t = thickness of pipe wall

r = mean radius of pipe cross-section

R = radius of bend

$\lambda = \dfrac{tR}{r^2}$

$K = \dfrac{1 + 12\lambda^2}{10 + 12\lambda^2}$ = rigidity multiplication factor, and

y = distance of element considered from neutral axis.

Values of longitudinal stress S_l, transverse stress S_t, and equivalent stress $S_l - S_t$ determined by these theoretical formulas are given in Table 2.

A graphical comparison of the theoretical stress distribution thus obtained with that obtained experimentally is shown in Figs. 10 and 11. It will be seen that at both points A and B (Fig. 1) the actual stress distribution agrees fairly closely with that determined theoretically. However, the longitudinal stresses on the inside of the bend will be seen to be somewhat larger than those calculated. This is due to the fact that the pipe bend acts as a curved bar and consequently the stresses on the inside of the bend will be larger than the corresponding ones on the outside. This effect was neglected in the theoretical derivation in order not to greatly complicate the theory. The theoretical and experimental curves of "equivalent stress" $S_l - S_t$ also agree quite well. For comparison, the longitudinal stress computed by the usual bending theory is also shown. The maximum "equivalent stress" as measured experimentally also differs but little from that calculated theoretically, using Equation [12] of the aforementioned paper.[4] This indicates that the formula in question is sufficiently accurate for the practical determination of true equivalent stress in pipe bends. Referring to Figs. 10 and 11, it will be seen that the maximum equivalent stress as measured was about twice that given by the usual bending theory and represented by the straight line shown. In view of this fact it is not surprising that pipe bends designed by the conventional theory when cold sprung often do not return to their original position when unbolted and removed from service, since the material has been stressed beyond the elastic limit although the stresses indicated by the conventional theory were well below the elastic limit.

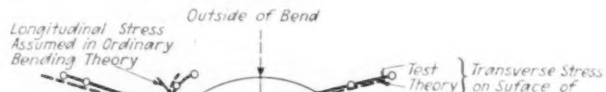

FIG. 10 STRESS DISTRIBUTION AT POSITION A (FIG. 1) DUE TO EXTERNAL BENDING MOMENTS

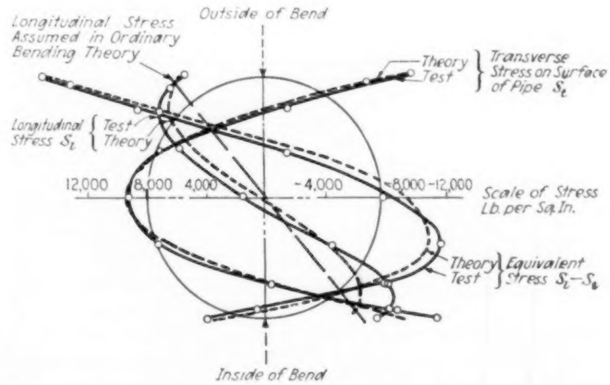

FIG. 11 STRESS DISTRIBUTION AT POSITION B (FIG. 1) DUE TO EXTERNAL BENDING MOMENTS

TABLE 2 STRESS DISTRIBUTION AS CALCULATED AT POSITIONS A AND B

	Point on pipe circumference, Fig. 5								
	1	2	3	4	5	6	7	8	9
Longitudinal stress S_l	5,410	5,940	6,400	4,290	0	−4,290	−6,400	−5,940	−5 410
Transverse stress S_t	−9,530	−6,750	0	6,750	9,530	6,750	0	−6,750	−9,530
Equivalent stress $S_l - S_t$	14,940	12,690	6,400	−2,460	−9,530	−11,040	−6,400	810	4,120

STRESSES DUE TO INTERNAL PRESSURE

In determining the stresses set up by internal pressure from the measured strains, we must, as before, take into account strains produced by stresses acting at right angles to theses trains. We may therefore use Equation [1] ante. Since longitudinal-strain measurements were taken at only a few points, the average value of the longitudinal strain e_l found at positions B and C (Fig. 12) was assumed for all sections. Since in all cases e_l is small relatively to e_t, and since only 0.3 of e_l is taken in the formula, a considerable error in e_l would make only a small error in the resulting value of stress.

In determining the longitudinal stresses at position C from the measured strains we use Equation [1], except that e and e_t are interchanged and S_l is substituted for S_t. In this we assume as before that $E = 29 \times 10^6$ and $1/m = 0.3$.

Values of stresses, both longitudinal and transverse, obtained in this manner at the various points of the pipe (Fig. 12) and at various points of the circumference are shown in Table 3.

TABLE 3 STRESSES DUE TO 1000 LB. PER SQ. IN. INTERNAL PRESSURE

Position on pipe[1]	Kind of stress	Ellipticity	Position on circumference (Fig. 5) 1	2	3	4	5	6	7	8	9
B	Transverse	0.075 in.	15,500	13,100	10,100	5,300	3,900	3,000	5,800	11,200	17,000
C	Transverse	0.01 in.	9,600	...	7,800	..	9,700	..	8,000	...	10,100
	Longitudinal	0.01 in.	4,500	...	...	..	4,700	..	..	...	5,000
D	Transverse	0.12 in.	16,100	...	...	..	−900	..	..	...	24,900
E	Transverse	0.086 in.	6,300	...	...	..	17,200	..	...	...	1,400

[1] These letters refer to Fig. 12.

In the third column are given the values of ellipticity of the cross-section at positions B, C, D, and E. In all cases the major axis of the ellipse was approximately perpendicular to the plane of the bend except at position E where it was in the plane of the bend.

A graphical picture of the transverse stress distribution on the outside of the pipe due to 1000 lb. per sq. in. internal pressure at position B, Fig. 12, is shown by the shaded area of Fig. 13.

It will be noted that the transverse stress varies greatly with the ellipticity, i.e., at points where the ellipticity is great the value of maximum transverse stress is correspondingly high. At position C, where the ellipticity is practically zero, the variation in transverse stress is small, while at point D, where the ellipticity is a maximum, the variation is from —900 lb. per sq. in. (compression) to 24,900 lb. per sq. in. (tension). At position E, where the major axis of the ellipse is in the plane of the bend, the maximum stress, instead of being at point 9, is at point 5 (Fig. 5). The maximum stress was found near the extremity of the minor axis of the ellipse, as might be expected, indicating that these stresses are due to the initial ellipticity of the cross-section.

In the case of a pipe bend having a slightly elliptical cross-section and subjected to internal pressure, we may consider an element of the bend cut out by two adjacent planes perpendicular to the axis to be a slightly elliptical ring subjected to internal pressure. We may therefore use the analysis of Appendix No. 5 of the aforementioned paper.[4] (See Figs. 36 and 37 of that paper.)

This slightly elliptical ring, which is assumed to be of unit axial length, will at any point of its circumference be subjected to a bending moment and a normal force, which will set up both bending and direct tensile stresses.

In order to calculate these stresses the authors use Equation [49] of the aforementioned paper,[4] which gives the maximum bending moment acting on a slightly elliptical ring of unit axial length subjected to internal pressure. This is:

$$M_0 = pr\delta$$

where M_0 = bending moment per unit axial length at point of maximum stress

p = internal pressure, lb. per sq. in.

δ = ellipticity, inches

r = radius of pipe cross-section, inches.

The stress set up by this bending moment is equal to $6M_0/t^2$, where $t^2/6$ is the section modulus of a strip of the pipe wall of thickness t and of unit width. On this stress it is necessary to superimpose the stress due to direct circumferential tension, which is pr/t. The stresses calculated in this way are compared in Table 4 with those found experimentally. In making the calculations r was taken as 4.9 in., i.e., half the inside diameter, and t was assumed as 0.48 in., which value was found, as mentioned earlier, at section A, Fig. 12.

It will be seen that the calculated stresses agree within reasonable limits with those measured.

Further tests along this line in order to fill up the gaps of Table 4, combined with more accurate and painstaking measurements of ellipticity and thickness at various sections, would be desirable for further corroboration of this formula.

The important thing to note in this connection is the very considerable stresses produced by internal pressure.

Deflection of the Pipe and Distortion of the Cross-Section

The deflection of the end D of the pipe (b, Fig. 1) with respect

TABLE 4 COMPARISON OF CALCULATED AND MEASURED STRESSES DUE TO INTERNAL PRESSURE

Position on pipe (Fig. 12)	Approximate ellipticity, inch	Calculated maximum stress (transverse)	Measured maximum stress (transverse)
B	0.075	19,600	17,200
C	0.01	11,100	10,100
D	0.12	28,500	24,900
E	0.086	22,000	17,200

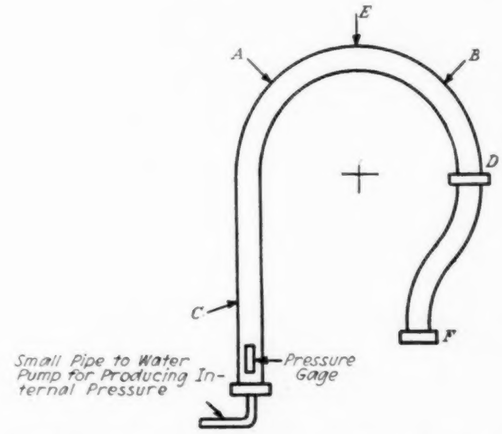

FIG. 12 METHOD OF TESTING PIPE FOR STRESSES SET UP BY INTERNAL PRESSURE

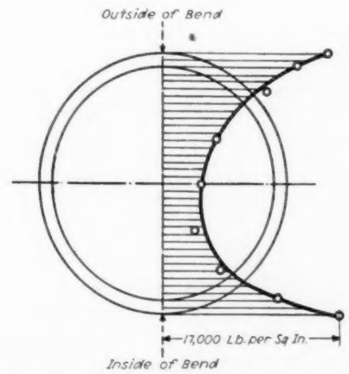

FIG. 13 TRANSVERSE STRESS DISTRIBUTION ALONG OUTSIDE OF PIPE CROSS-SECTION DUE TO INTERNAL PRESSURE OF 1000 LB. PER SQ. IN. AT POSITION B (FIG. 12); ELLIPTICITY = 0.075 IN.

to the end C was computed for a load of 1830 lb., corresponding to $2^1/_2$ in. deflection, using the methods outlined in the paper previously referred to.[4] Values of dimensions given earlier in the present paper were used. The value of deflection thus computed was 2.11 in., which is less than the value of 2.5 in. measured at that load. This discrepancy may probably be accounted for by a slight yielding of the support C (Fig. 2) and some distortion of the pipe cross-section at C, since it was not reinforced. Another probable cause of the discrepancy is the fact that accurate data on thickness were not available at all points of the bend. Since the deflection computed by ordinary methods, i.e., by neglecting the flattening of the cross-section, was only 1.22 in., we may conclude that the more exact theory gives results sufficiently close for practical work, and in much better agreement with test results than the ordinary theory. However, sufficient work has been done by other investigators to show the correctness of the Karmán theory when applied to the calculation of deflection in piping, if the end conditions are known.

TABLE 5 COMPARISON OF CALCULATED AND MEASURED AMOUNTS OF DISTORTION OF PIPE CROSS-SECTION DUE TO EXTERNAL BENDING MOMENT

Position on pipe (Fig. 1)	Measured change in vertical diameter under load, inch	Measured change in horizontal diameter under load, inch	Calculated change in diameter, inch
A	0.025	0.0248	0.0241
B	0.0226	0.025	0.0241

The distortion of the pipe cross-section at a load of 1830 lb. both in the plane of the bend and perpendicular to the plane of the bend were measured by means of a micrometer at positions A and B (Fig. 1). These distortions were calculated by the use of Equation [13], of the aforementioned paper,[4] the dimensions given in Fig. 1 being used. The calculated amounts of distortion together with those measured experimentally are given in Table 5.

Since an error in measurement of the distortion of 0.001 in. may easily have occurred, it is seen that the calculated distortions check the theoretical within the limits of experimental error. This fact affords another check on the correctness of the theory.

It was also noted that the ends of the pipe opened up 0.27 in. under an internal pressure of 1000 lb. per sq. in., i.e., the distance between C and F (Fig. 12) increased this amount on application of 1000 lb. per sq. in. internal pressure. This corresponds to a load of 200 lb. on the ends of the pipe, which would set up only very low stresses. This would indicate that the reactions at the ends of pipe bends set up under steam pressure are not of great importance. Further work along this line would, however, be desirable.

Conclusions

This investigation shows that the formula derived by one of the authors in his previous paper[4] and later by another investigator[5] for computing equivalent stress and deflections for given end conditions in pipe bends is sufficiently accurate for practical application in pipe-bend design. The measurements of the distortion of the cross-section further corroborate the theory.

Another important point brought to light by these tests was the very considerable stress induced by internal pressure in pipe bends having initial ellipticity of the cross-section.

These stresses, when superimposed on those due to bending moments, may result in stresses sufficiently high to produce permanent set in the piping. This permanent set may tend to nullify the effect of cold springing, allowing possibly excessive reactions on anchors, turbine casings, etc. For these reasons it might be desirable to specify certain limits regarding the permissible ellipticity of the cross-section of pipe bends.

The authors wish to express their indebtedness to Messrs. J. L. Ray, N. L. Mochel, and other Westinghouse engineers for their assistance.

The Flow of Fluids

THE modern treatment of the subject of the flow of fluids originated with the researches of Osborne Reynolds some fifty years ago. Poiseuille, in 1846, published the result of his study of the flow of water through capillary tubes, in which he confirmed that the loss of head was directly proportional to the mean velocity of flow. This result was shown to be in agreement with the mathematical theory which may be deduced quite simply from first principles by assuming that the motion is of a streamline or laminar character. The pipe experiments of Darcy, published in 1857, showed, in common with other large-scale experiments, that the loss of head was proportional to a power of the velocity which did not differ greatly from two.

Thus, experiment had demonstrated the existence of two definite and distinct laws of resistance: that of Poiseuille agreed with the mathematical theory, but, on the other hand, the experiments of Darcy, showing conditions of flow in which the resistance varied as the square of the velocity, indicated that the mathematical theory was of strictly limited application. The assumption of the eddying or turbulent character of the motion of the fluid in those cases in which the square law held, gave a physical meaning to the existence of the two laws, and explained the difference between the resistance observed by Darcy and that found by Poiseuille. A close examination of the theory, however, failed to show any reason why, on the one hand, it should predict phenomena of the type observed by Poiseuille, and yet, on the other hand, give no indication of any limit to such streamline flow.

Reynolds, in giving an explanation of this state of affairs, cleared up what at the time was a most obscure matter. He introduced streams of colored liquid into the main stream of water flowing through a glass pipe, and showed visually that two types of flow could occur even in the same pipe. With small velocities, the line of color remained perfectly straight and unbroken, indicating that each layer of the fluid was moving in the same direction. If the velocity were gradually increased, then this régime continued until some particular or critical velocity was reached, at which the line of color suddenly and completely broke up, and intermingled with the rest of the water within the tube, thus indicating that the motion had changed to one of a completely eddying or turbulent type. His various tests showed that the critical velocity at which the change occurred depended upon the size of the tube and the temperature of the water. He next demonstrated that a corresponding change in the law of resistance took place with the change in the type of motion.

In order to explain the factors which governed the magnitude of the velocity at which the transfer from laminar to turbulent flow took place, Reynolds applied dimensional reasoning to practical hydraulics. In doing so, he may be said to have laid the foundation for the more recent research. The reasoning is based on the fact that any particular velocity must be defined either in terms of the standards of comparison for length and time, or simply in terms of some other velocity, that is, as a ratio.—S. J. Davies and C. M. White in *Engineering*, July 19, 1929, p. 69.

The State of Stress in Thin-Walled Pressure Vessels[1]

A Rapid Method of Analyzing Stresses Which Yields Results in Agreement With Those Obtained by Other Methods and by Experiment

By W. M. COATES,[2] ANN ARBOR, MICH.

The vessel considered in the present analysis is under a uniformly distributed inner pressure, and has the following characteristics:

- A cylindrical drum, whose length exceeds its diameter (see the discussion of the numerical example, given later)
- Full heads, whose meridional tangents at the junction with the cylinder lie in the latter
- Depth of head b not too small a part of the radius of the cylinder a; for example, $a/b = 2$ is a favorable ratio from the point of view of stress distribution
- Thickness of shell t small in comparison with a.

Shells which do not resist bending will be called "membranes." Experience has shown the assumption that the walls of the vessel behave as membranes to be satisfactory at sufficient distance from their edges, or possible holes, or points where there is a sudden change in the radius of curvature or thickness, etc. The neighborhood of such discontinuities in the nature of the shell, however, needs closer investigation.

For example, under uniform inner pressure a cylindrical membrane has a radial displacement about 2.4 times that of a hemispherical one of the same initial radius (see Fig. 1). If the hemisphere be replaced by an ellipsoid of depth b less than a, the above ratio becomes greater; below a certain depth, $b = 0.77\,a$, the equatorial hoop of the ellipsoid contracts instead of expanding. (See Fig. 2.) From this, and the fact that in the actual vessel the head and the cylinder keep together at the edge, it is seen that they do not behave as membranes but rather as shells capable of resisting forces normal to their middle surfaces, as well as bending couples acting in meridional planes. Each shell, head, and cylinder experiences reactions from the other as shown in Fig. 3(a).

The investigation of the state of stress in such a vessel may be conveniently divided into:

1 That of the cylinder and heads as membranes

2 That due to the mutual reactions set up at the junction.

The resultant stress at any point is then obtained by superposition of the above stresses.

Equations Used in Analysis of Stresses

The membrane analysis is made by the following equations, which are obtained from the statical conditions of equilibrium:

For cylinder: $\sigma_1 = \dfrac{pa}{2t}$, $\sigma_2 = \dfrac{pa}{t}$

For head:

$$\left.\begin{aligned} \sigma_1 &= \frac{pR_2}{2t} \\ \sigma_2 &= \sigma_1\left[2 - \frac{R_2}{R_1}\right] \end{aligned}\right\} \quad \ldots\ldots\ [1]$$

in which σ_1 and σ_2 are the normal stresses in the directions of the meridional and hoop tangents, respectively; R_1 is the radius of curvature of the meridian, and R_2 that of the curve cut from the surface by a plane normal to the meridian at the point in question; p is the intensity of the uniformly distributed inner pressure; and a and t are, as stated, the radius and the thickness of the cylinder. (See Fig. 4.)

The analysis of the junction stresses for the cylinder is made by

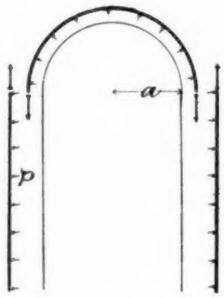

Fig. 1

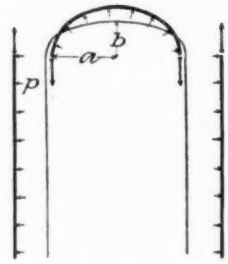

Fig. 2

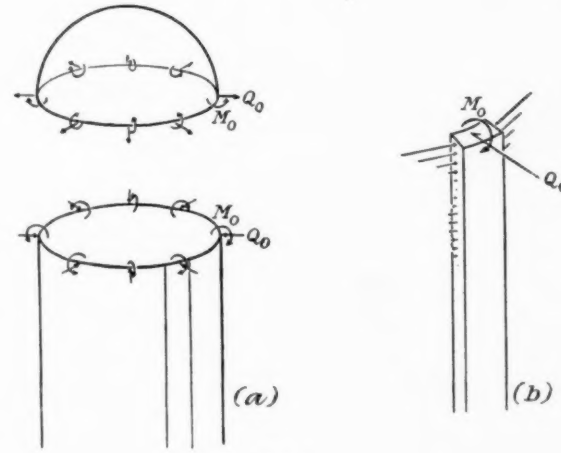

Fig. 3

considering the strip shown in Fig. 3(a). The loads on this strip, applied at the end, are: the shearing force Q_0 and the bending couple M_0, each per unit of arc of the edge circle. The other forces acting on this body are the hoop forces and the bending couples set up across longitudinal sections by the end loads. The hoop forces come out to be proportional to the displacement. The strip, isolated in Fig. 3(b),[3] behaves as a beam on an elastic foundation under the end loads Q_0 and M_0, and the stresses may be found in terms of these loads. A similar analysis gives approximate values for the head. The condition that the edges of cylinder and head meet with a common tangent at the junction,

[1] Abstract of a dissertation to appear in full as an Engineering Research Bulletin of the University of Michigan.

[2] Instructor in Engineering Mathematics, University of Michigan.

[3] The bending couples are not shown in the figure, but they are taken into consideration, and the stresses which they cause are computed.

determines the value of Q_0 and M_0. In case the head and shell are of the same thickness, these are:

$$\text{and}\quad \left.\begin{array}{l} Q_0 = \dfrac{pk^2}{8\lambda_0} \\ M_0 = 0 \end{array}\right\} \quad \text{where} \quad \left\{\begin{array}{l} k = \dfrac{a}{b} \\ \lambda_0 = \sqrt[4]{\dfrac{3(1-\mu^2)}{a^2t^2}} \\ \mu = \text{Poisson's ratio} \end{array}\right.$$

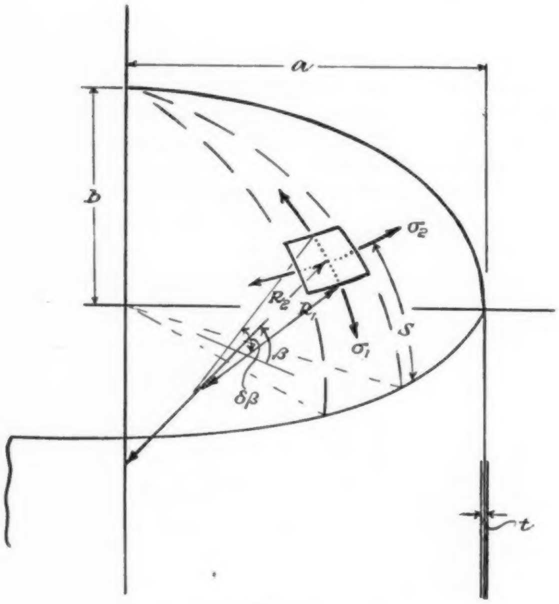

Fig. 4

Then the most significant of the stresses due to the mutual reactions at the junction are:

For cylinder:

$$\sigma_2 = -\frac{pk^2a}{4t}e^{-\lambda_0 s}\cos\lambda_0 s$$

$$\sigma_{1e} = +\frac{3pk^2}{4\lambda_0^2t^2}e^{-\lambda_0 s}\sin\lambda_0 s$$

For head: . . . . [2]

$$\sigma_2 = \frac{pk^2a}{4t}\frac{a}{R_2}\left(e^{-\int_0^s \lambda ds}\right)\cos\int_0^s \lambda ds$$

$$\sigma_{1e} = -\frac{3pk^2}{4\sqrt{3(1-\mu^2)}}\frac{a^2}{tR_2}\left(e^{-\int_0^s \lambda ds}\right)\sin\int_0^s \lambda ds$$

where σ_{1e} is the normal stress in the outer fibers due to bending, and the distribution of these bending stresses is assumed to be linear over the thickness, with the value zero at the middle surface and maximum in the boundary surfaces of the shell; s is the distance away from the junction, measured along the element of the cylinder, or along the meridian of the head; and, for the head, λ is variable with R_2 and given by the equation

$$\lambda = \sqrt[4]{\frac{3(1-\mu^2)}{R_2^2t^2}}$$

The integral involved here may be rapidly evaluated numerically, as in the example worked out below.

The equations given above involve the functions $e^{-\lambda s}\sin\lambda s$ and $e^{-\lambda s}\cos\lambda s$ which are characteristic of the problem of a beam on an elastic foundation, and have been tabulated (see Timoshenko and Lessells, "Applied Elasticity," p. 138). They are oscillatory from the trigonometric functions involved, with amplitudes very rapidly damped out by the factor $e^{-\lambda s}$. Curves I and II of Fig. 5 display them against values of λs as abscissas. The ratio of successive critical ordinates is 1/23.1, and the width of the interval between them is $2.44\sqrt{at}$, exactly for the cylinder and approximately for the head. The greatest value of $e^{-\lambda s}\cos\lambda s$ is 1, and occurs at the edge; the maximum of $e^{-\lambda s}\sin\lambda s$ is $e^{-\pi/4}\sin\frac{\pi}{4} = 0.32$, and occurs at $s = \frac{\pi}{4\lambda_0} = 0.61\sqrt{at}$.

A convenient method of computing from these formulas is given in the following example.

Example of Computation

The vessel has ellipsoidal heads and the following dimensions:

a = radius of cylinder = semi-major axis of ellipse = 40 in.
b = depth of head = semi-minor axis of ellipse = 20 in.
k = a/b = 2
t = thickness of shell (same for cylinder and head) = 1.25 in.
μ = Poisson's ratio = 0.3 here
E = Young's modulus = 3×10^7 lb. per sq. in.
p = 100 lb. per sq. in.

A rapid analysis to get the maximum stresses, or those at other particular points, is as follows:

Membrane Analysis (Eq. [1])

For cylinder:

$\sigma_1 = 1600$
$\sigma_2 = 3200$

For head:

At edge $R_1 = \frac{b^2}{a} = 10$; $R_2 = a = 40$; $\sigma_1 = 1600$; $\sigma_2 = -3200$

At dome $R_1 = 80$; $R_2 = 80$; $\sigma_1 = 3200$; $\sigma_2 = 3200$

Analysis of Junction Effects (Eq. [2])

For cylinder:		For head:
$\sigma_2 = -\frac{pk^2a}{4t} = -3200$	(Occurs at edge $s = 0$)	Same with sign reversed
$\sigma_{1e} = \frac{3pk^2}{4t^2\lambda_0^2}(0.32) = 1890$	(Occurs at $s = 0.61\sqrt{at} = 4.3$)	Approximately the same with sign reversed and s laid off along the meridian. (The approximation is rough.)

A more thorough analysis to determine the distribution of this latter group of stresses may be made by use of Eq. [2].

For cylinder:

$\lambda_0 = 0.182$
$\sigma_2 = -3200e^{-\lambda_0 s}\cos\lambda_0 s$
$\sigma_{1e} = +5820e^{-\lambda_0 s}\sin\lambda_0 s$

For head:

$$\int^s \lambda ds = 1.15\int_0^s \frac{ds}{\sqrt{R_2}}$$

$$\sigma_2 = +\frac{128{,}000}{R_2}\left(e^{-1.15\int_0^s \frac{ds}{\sqrt{R_2}}}\right)\cos\left(1.15\int_0^s\frac{ds}{\sqrt{R_2}}\right)$$

$$\sigma_{1e} = -\frac{232{,}700}{R_2}\left(e^{-1.15\int_0^s \frac{ds}{\sqrt{R_2}}}\right)\sin\left(1.15\int_0^s\frac{ds}{\sqrt{R_2}}\right)$$

For the cylinder the values of the functions are found by assigning values to $\lambda_0 s = X$ in Fig. 5, and picking off the corresponding ordinates. The stresses are displayed in the dotted curves in Figs. 6 and 7.

For the head, the value of $\int_0^s \frac{ds}{\sqrt{R_2}}$ for any value of s may be found conveniently in terms of the angle β (see Fig. 4) from the relationship $\delta s = R_1\delta\beta$ and

$$R_2 = kav = \frac{ka}{\sqrt{1 + (k^2 - 1)\cos^2\beta}}$$

It is seen that δs and R_2 are not constant, but may be so regarded if the interval $\delta\beta$ be taken so short that the variation of R_1 and R_2 within it is negligible. Then we may compute $\delta s/\sqrt{R_2}$ for each such interval, and at any β such as β_n we may write:

$$\int_0^s \frac{ds}{\sqrt{R_2}} = \sum_{\beta = 0}^{\beta_n} \frac{\delta s}{\sqrt{R_2}}$$

The computation is shown in Table 1, and goes nicely on a slide rule; in this case a K. & E. log-log rule was used. From the value of β, column 2 is filled as follows:

$$\beta = 10^\circ \qquad v = \frac{1}{\sqrt{1 + 3\cos^2 10^\circ}}$$

On the rule, square sin 80° by use of the S- and A-scales; multiply by the left 3 on the B-scale to get 2.91 on the A-scale; add 1 mentally, move runner to 3.91 on B-scale, turn rule over and read 0.506 on the CI-scale; tabulate in column 2.

Column 3 gives the values of R_1 at the hoops $\beta = 0°, 5°$, etc. (the second subscripts in this table may be disregarded), and column 4 gives average values for the zones included. Similarly for R_2 in columns 6 and 7. In column 5 it is recalled that $\delta\beta$ is expressed in radians. A sample computation to get column 8 is the following: $\beta = 10°$, R_2 from column 7 is 40.3. On the rule, move runner to 40.3 on right A-scale; turn rule over and bring $\delta s = 0.894$ (from col. 5) on C-scale to the hairline; read value 0.140 on C-scale over left index on D-scale, and tabulate in column 8.

Each entry in column 9 is the sum of the entries in column 8 down to and including its level β_n and represents

$$\sum_{\beta = 0}^{\beta_n} \frac{\delta s}{\sqrt{R_2}}$$

From the entries in column 10 as abscissas, the values of the functions tabulated in columns 11 and 12 are found as ordinates on curves I and II in Fig. 5. The results are displayed in the dotted curves of Figs. 6 and 7, the length s along the meridian curve being obtained by adding up the arcs δs. Column 15 gives displacements normal to the surface.

It is seen from columns 4 and 7, or finally from column 8, that the interval $\delta\beta$ may be chosen longer near $\beta = 0$, and shorter as we progress. However, columns 13 and 14 show that the values of

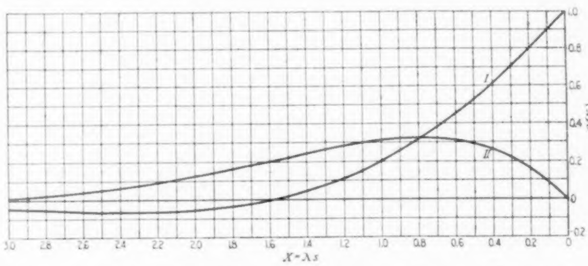

FIG. 5 THE CHARACTERISTIC FUNCTIONS $f_1(X) = e^{-X}\cos X$ AND $f_2(X) = e^{-X}\sin(X)$

the stresses decrease numerically as β increases, hence we expect to stop the computation as soon as they become negligible or even as soon as we pass the maximum σ_m. There is nothing about the method which requires a constant length of interval $\delta\beta$, and experience with the method of computation applied to usual designs will enable a choice of intervals which will give desired accuracy with the least computation.

The resultant stresses are shown in Figs. 6 and 7 by the dot-dash curves. The bending stresses σ_{1e} there shown are those at the outer surface. For the inner surface their signs are reversed, and then the dot curves which display them should be reflected in the line giving the contour of the vessel.

TABLE 1 THE DISCONTINUITY STRESSES AND DISPLACEMENT

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
β deg.	v	$R_{1n} = kav^3$	$R_{1N} = \frac{R_{1n} + R_{1n+1}}{2}$	$\delta s = R_{1N}\delta\beta$	$R_{2n} = kav$	$R_{2N} = \frac{R_{2n} + R_{2n+1}}{2}$	$\frac{\delta s}{\sqrt{R_{2N}}}$	$\sum \frac{\delta s}{\sqrt{R_{2N}}}$	$X = 1.15 \sum \frac{\delta s}{\sqrt{R_{2N}}}$	$e^{-X}\cos X$	$e^{-X}\sin X$	σ_2	σ_{1e}	$W \times 10^6$
0	0.500	10.0		0.000	40.0		0.000	0.000	0.000	1.00	0.00	3200	0	430
			10.03			40.1								
5	0.501	10.1		0.875	40.1		0.138	0.138	0.159	0.843	0.135	2690	− 684	363
			10.22			40.3								
10	0.506	10.38		0.894	40.5		0.140	0.278	0.320	0.688	0.229	2190	−1320	296
			10.59			40.8								
15	0.513	10.80		0.924	41.1		0.144	0.422	0.485	0.543	0.287	1700	−1635	234
			11.13			41.5								
20	0.523	11.45		0.972	41.9		0.150	0.572	0.657	0.411	0.317	1270	−1773	177
			11.95			42.5								
25	0.538	12.45		1.043	43.1		0.160	0.732	0.842	0.287	0.322	860	−1763	123
			13.06			43.8								
30	0.555	13.66		1.14	44.4		0.172	0.904	1.039	0.180	0.306	530	−1630	78
			14.47			45.3								
35	0.576	15.28		1.26	46.1		0.187	1.091	1.255	0.088	0.271	250	−1400	38
			16.37			47.2								
40	0.602	17.45		1.43	48.2		0.207	1.298	1.491	0.018	0.224	50	−1100	8
			18.80			49.4								
45	0.632	20.15		1.64	50.6		0.233	1.531	1.761	−0.033	0.169	−80	−795	−14
			22.00			52.1								
50	0.668	23.85		1.92	53.5		0.265	1.796	2.070	−0.060	0.110	−150	−490	−26

In general, the greatest values are to be expected at the dome, the inner surface at the knuckle, and the outer surface of the

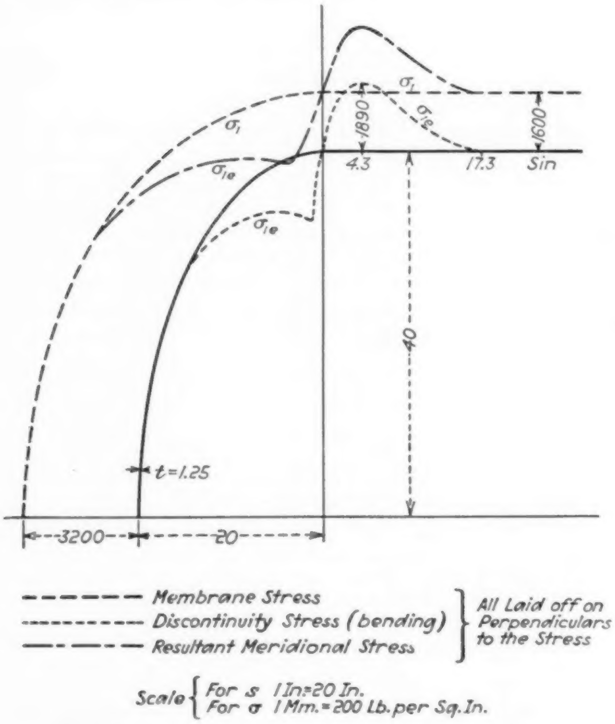

FIG. 6 THE MERIDIONAL STRESSES σ_1 AND σ_{1e}

cylinder near the junction; here they are all about 3500. After one criterion, the favorable head, from the point of view of stress distribution, keeps these key stresses about equal, and thus

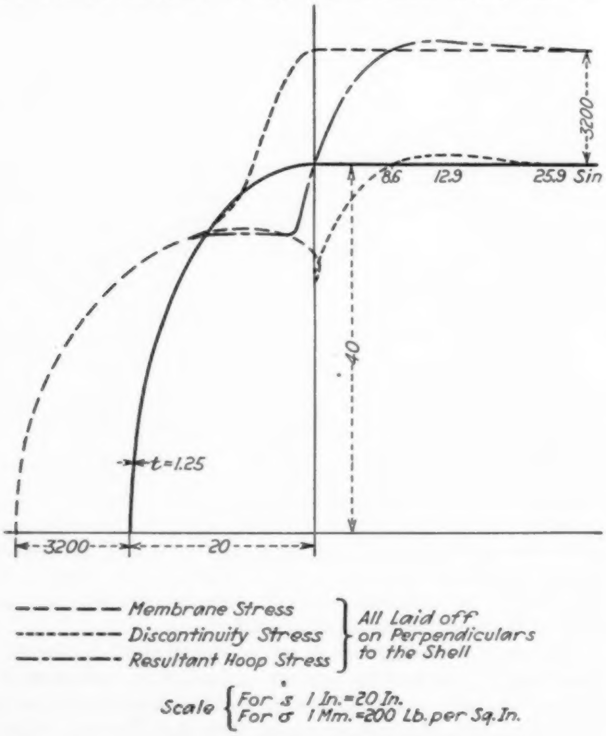

FIG. 7 THE HOOP STRESSES σ_2

the case taken is a favorable one. It should be noted that there is a compressive hoop stress and a tensile meridional stress at the inner surface of the knuckle, and consequently a high stress difference, with the attendant possibility of failure due to shear as the load p is increased. This is especially to be kept in mind in the usual design, which gives a much higher meridional stress here.

CONCLUSION

In conclusion, it is seen that the stresses set up by the reactions at the junction of head and cylinder are important parts of the resultant stresses, and may be calculated for such vessels as hypothesized. The zone of their importance is controlled in width by the factor $\sqrt{at}$, and thus an increase of the wall thickness lengthens this zone. The position of the maximum bending stress depends also on the same factor. The results obtained are in agreement with those yielded by other methods and by experiment[4] but there is need for more quantitative verification.

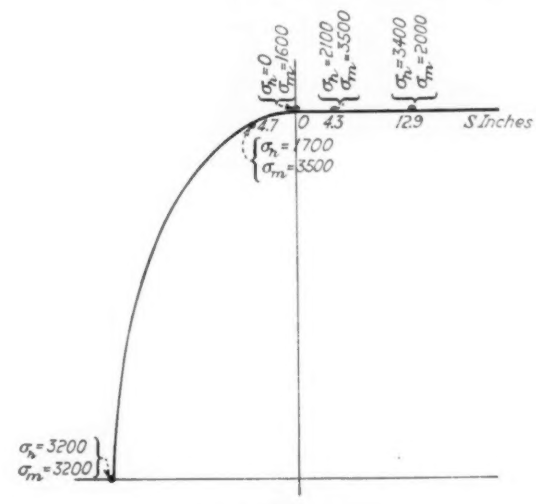

FIG. 8 KEY STRESSES

σ_h = resultant hoop stress } In outside fibers if written outside contour
σ_m = resultant meridional stress } In inside fibers if written inside contour
s is measured away from the junction along the contour.
Scale: 1 in. = 20 in.

This may be made by strain and deflection measurements, and the data obtained will also show the accuracy with which the edge values of Q_0 and M_0 are realized. The method permits the introduction of these data to give a closer prediction of the stresses which the reactions set up.

A new metal, known as "Konel," is credited with being much stronger than other metals at high temperatures, and is suitable for use in the moving parts of internal-combustion engines and other extremely hot places. Originally developed in the Westinghouse Company's Research Laboratories as a substitute for platinum in the manufacture of filaments for wireless valves, the new metal was discovered to be harder to forge than steel, and to be very tough at high temperatures, when most metals lose their strength. The cost is given as being only a few dollars a pound.—*The Engineer*, Aug. 30, 1929, p. 225.

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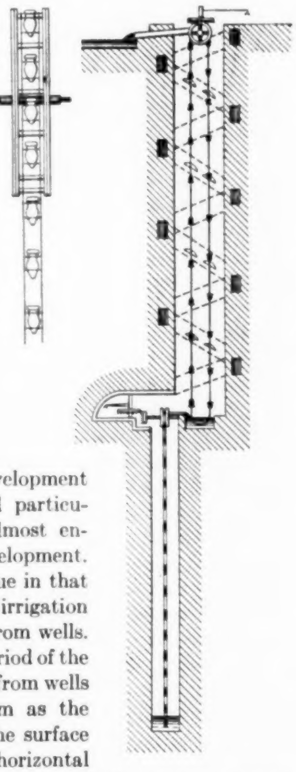
[4] J. Geckeler, "Über die Festigkeit achsensymmetrischer Schalen," Forschungsarbeiten, V.D.I., No. 276.

Höhn-Huggenberger, "Über die Festigkeit der gewölbten Böden und der Zylinderschale," Springer, Berlin, 1927.

The Development of the Deep-Well Turbine Pump

By W. H. Holcomb,[1] San Francisco, Calif.

In considering the advances made in the modern design and application of water-development equipment which plays so important a part in the progress of the West it is interesting to note that this same problem has been faced since the beginning of civilization. Water supplies were developed by inhabitants of ancient cities many centuries before Christ. These supplies frequently were secured from wells dug either in the solid rock or in looser formation and walled with rock. These wells were from 3 ft. to 9 ft. in diameter, and in some cases were more than 200 ft. deep. Probably the most outstanding piece of ancient engineering was Joseph's Well at Cairo, dug about the time the pyramids were built, in the neighborhood of 3000 B.C. This well was 18 ft. × 24 ft. square and 295 ft. in depth; two lifts were used to pump the water, the upper being 160 ft. and the lower 135 ft. The design of pump used was far remote from those in service today and consisted of an endless chain of buckets pulled by oxen. In order to get oxen down to the 160-ft. level a spiral path was made around the upper section of the well, a considerable achievement in itself.



Scheme of Joseph's Well

As in the case of ancient civilizations, the progress and development of the southwestern states and particularly California is dependent almost entirely on successful water development. This territory is somewhat unique in that a large portion of the water for irrigation and commercial use is obtained from wells. During the early development period of the Southwest the pumping of water from wells presented no particular problem as the water table was very close to the surface and the conventional type of horizontal centrifugal pump installed on the ground or in a shallow pit was employed to advantage.

However, as more and more land was placed under irrigation the water table commenced to drop, eventually reaching a point in most territories where the continued use of the horizontal-shaft pump was no longer practical, due, of course, to the excessive cost of the deep pits and the inconvenience of operation. The condition created by the lowering water table and the constantly increasing acreage under irrigation required the extensive application of a type of well pump which could be easily lowered with the water table and which did not require an expensive pit. The solution of the problem was found in the deep-well turbine pump, of which it is estimated from five to seven thousand are installed each year in California alone, and probably an equal number in the remainder of the southwestern states. When it is considered that the average setting or depth of the deep-well pumps used in irrigation work is between 70 and 80 ft., it will be readily appreciated that this number of pumps represents a very substantial industry in itself.

This type of pump is normally installed in a drilled well usually from 1 in. to 4 in. larger in diameter than the diameter of the pump bowls. The wells are cased with steel which is perforated at each water-bearing strata. This casing in general extends to the bottom of the well and practically always to a depth greater than the bottom of the pump setting. The method used in drilling the wells follows closely that used in oil wells, and the advances made in the well-drilling industry have paralleled those made by the pump manufacturers.

The Deep-Well Turbine Pump Not a New Development

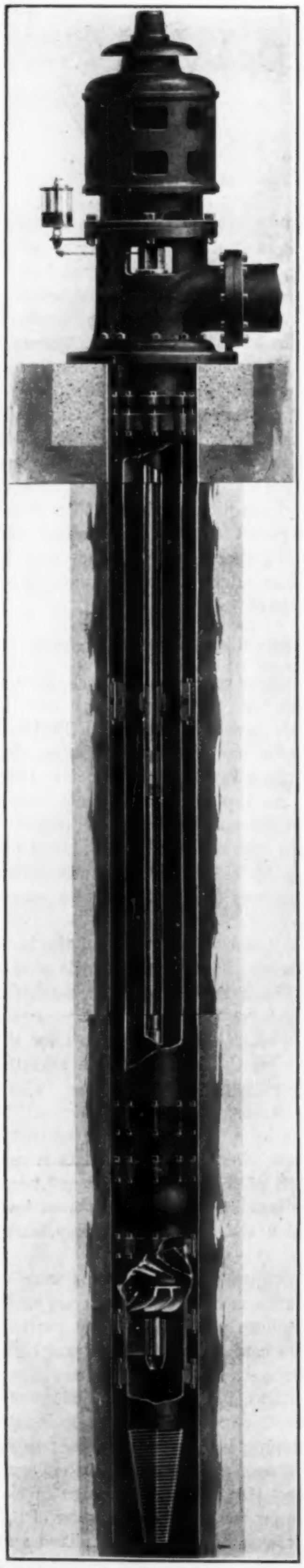
While the deep-well turbine pump cannot in any sense be considered a new development, the first on record being a unit installed in Chicago by the Byron Jackson Company in 1901 and the first unit in California being one installed at Chino, San Bernardino County, by the Layne & Bowler Corporation in 1907, it is nevertheless a fact that no type of pumping equipment has witnessed as great an improvement during the past ten years. It is also true that this development is due almost entirely to the demand built up by the irrigation requirements of the Southwest and carried out very largely by western manufacturers.

The deep-well turbine pump consists essentially of the bowl assembly or pump proper, made up of one or more bowls or casings each having a diffuser section and impeller, a discharge column with delivery pipe, shafting, couplings, and bearings, and in most cases a shaft tube which acts as a support for the column shaft bearings and carries the lubricant. In addition there is of course the driving element or pump head, which may be arranged for electric-motor, gear, or belt drive. In most cases the pump is driven by a vertical electric motor of the hollow-shaft or built-in type where the pump shaft is carried up through the hollow shaft of the motor to a thrust bearing at the upper end bell, this bearing carrying the thrust load of both pump and motor plus the weight of the rotating element.

The earlier installations of deepwell turbine pumps were of the slow-speed type requiring large wells for comparatively small volumes, and in the light of modern practice were not particularly efficient. In addition the cost of manufacture was high, and as a result the pumps were only installed under conditions where no other type of equipment could be utilized. However, as the water tables in the Southwest dropped with increased irrigation and the cost of pumping became an ever-increasing factor in the delicate balance between success and failure in agriculture, both the hydraulic and the mechanical design of the deep-well pump were greatly improved. Also, by reason of the increased volume of manufacture as well as the simplified and improved design, the cost of manufacture was considerably reduced.

[1] Manager, Pump Department, Pelton Water Wheel Co., San Francisco, Calif.

Presented at a meeting of the San Francisco Section of the A.S.M.E., June 27, 1929.



Sectional Assembly of a Complete Deep-Well Turbine Pump in a Well

Operating Problems Encountered and Solved

As the application of the deep-well turbine pump became more general, many operating problems were encountered which necessitated improvements and changes in the design as originally built. In the first place, it was found that in order to successfully compete with the horizontal-shaft pump on medium settings where the water table was from 40 to 60 ft. below the ground, the efficiency of the pumps must be increased and also their mechanical reliability greatly improved to obviate the necessity of frequent dismantling which was expensive and required special equipment including a derrick, hoist, clamps, and other tools not available on the normal ranch or small municipal plant.

In the second place, it was found that the great amount of sand encountered in most wells was an exceedingly serious problem in that excessive wear took place on all of the rotating parts, particularly the bearings in both the bowl assembly and discharge column, and that occasionally the bowl assembly became sandlocked, making the pulling of the pump a difficult if not an impossible task.

A third problem which presented itself was the necessity of developing a design of impeller and bowl which would operate under the extreme range of head conditions occasioned by the seasonal fluctuations in the water table without overloading the prime mover and without sacrificing efficiency.

As the water tables continued to drop the cost of delivering the water to the land was gradually increased, due of course to the greater heads against which the pumps were required to operate, until in many districts a point was reached where further development or in fact continued operation of existing development was virtually impossible because of the high cost of the pumped water. Obviously this situation required an improvement in the design of the pumping equipment which would increase the efficiency of the pump to a point where the water delivered to the ground despite the increased lift would not require a very much greater expenditure for power.

As the volume of business in this type of pump increased and the various problems presented themselves, most of the larger manufacturers in the West undertook a program of research and experimental work which has nearly eliminated the difficulties encountered in the early pumps and has resulted in the development of equipment which can be successfully installed and operated under conditions which ten years ago would have been considered impossible to fulfil. These improvements have been general throughout the industry and have covered every part going to make up the complete unit. The large-sized slow-speed pumps as originally designed have been replaced by pumps designed to operate at speeds in the smaller sizes up to 3450 r.p.m., in sizes up to capacities of 2000 gal. per min., at speeds of as high as 1760 r.p.m. and in the larger sizes at speeds up to 1150 r.p.m. This has resulted in the securing of larger capacities from a given size of pump at an initial cost of one-half or one-third of the original types, the saving of course being due to the lighter weights of the various component parts and the lower costs of machining smaller parts as compared to the heavy parts used in the first pumps built.

Improvements in Hydraulic Design

As a result of the extensive research and experimental work carried out by the various manufacturers the hydraulic design of the deep-well turbine pump has been vastly improved. With the earlier types of pumps, efficiencies of 50 to 55 per cent were considered excellent, and probably the average efficiency of the pump installed prior to 1920 was below this value. Today it may be safely said that the average efficiency of the deep-well turbine pumps built by the larger manufacturers is from 65 to 75 per cent, and in some cases even greater. When it is considered that in arriving at these values the losses in the discharge column and discharge head are debited to the pump—in other words, the head is considered the actual difference in elevation between the level of the water in the well and the center line of the discharge opening—the improvement accomplished is almost phenomenal. As a result of these improved operating characteristics it is now entirely feasible and in fact practical to install a deep-well turbine pump under conditions where the head is as low as 20 ft., and under these low-head conditions to successfully compete with the horizontal or vertical pit pump.

The problem of prime-mover overloads with a varying head condition created by the fluctuation in the water table has been very largely eliminated, some manufacturers accomplishing this result by using a centrifugal type of impeller with a steep head-capacity characteristic giving an almost flat horsepower curve, and others by using an open or unshrouded impeller of the so-called "mixed flow" design which combines the virtues of both the centrifugal and screw pumps, and has a flat horsepower characteristic throughout the entire operating range of the pump, without sacrificing efficiency. This latter type of impeller has a further advantage in that the pressure changes through the impeller are low and consequently close running clearances subject to sand wear are not required, and the efficiencies obtained when the pump is first installed may be maintained throughout the operating life of the unit.

Sand troubles have been largely eliminated by improved bearing design, some manufacturers accomplishing this result in the bowl assembly by utilizing a grease-packed tail bearing with water-lubricated metal bearings at each stage, and others using stainless-metal shafts with cutless rubber tail and bowl

bearings which operate very successfully with water lubrication and are not subject to sand wear.

In practically all designs the upper main impeller shaft bearing, as well as the column shaft bearings, are enclosed in a so-called shaft tube which serves a triple purpose in that it supports the column shaft bearings rigidly, permits lubrication of these bearings from a single lubricator normally located on the pump head, and prevents sand from being carried to the bearings by the water being pumped. Two methods are used in lubricating the column bearings, the first employing a shaft tube filled with oil in which the bearings operate continuously, and the second having a drain section ported to the well above the upper bowl, the oil being fed into the top of the tube from a drip lubricator. With this system, as the column of oil in the tube develops a pressure higher than that of the water in the well at the drain section it is permitted to escape to the well, where of course it floats on top of the water.

In the majority of pump designs in use today column bearings are provided at frequent intervals, usually every 4, 5, or 6 ft. The column sections are made up in uniform interchangeable lengths, which greatly simplifies installation and readily permits adding a section in case the water level in the well drops, and without the necessity of pulling the entire pump.

The improvement in the design of the discharge heads or driving elements has kept pace with that of the remainder of the pump, and the head as used today bears very little resemblance to those originally built. With the higher-speed motors the discharge heads are of course a great deal smaller and require considerably less space; also the use of a head containing a separate thrust bearing for the support of the pump load and a flexible coupling to connect the shaft of the pump and motor have practically disappeared. In the design now used the motor is usually either built into the head by the pump manufacturer, using a single thrust bearing in the upper end bell of the motor, or a hollow-shaft motor is employed, the pump shaft being carried up through the hollow shaft of the motor to a single thrust bearing which carries the entire load. This not only simplifies construction but also makes it possible to easily adjust the position of the pump impellers by merely removing the upper end-bell cover of the motor which makes accessible the adjustment provided in the thrust bearing.

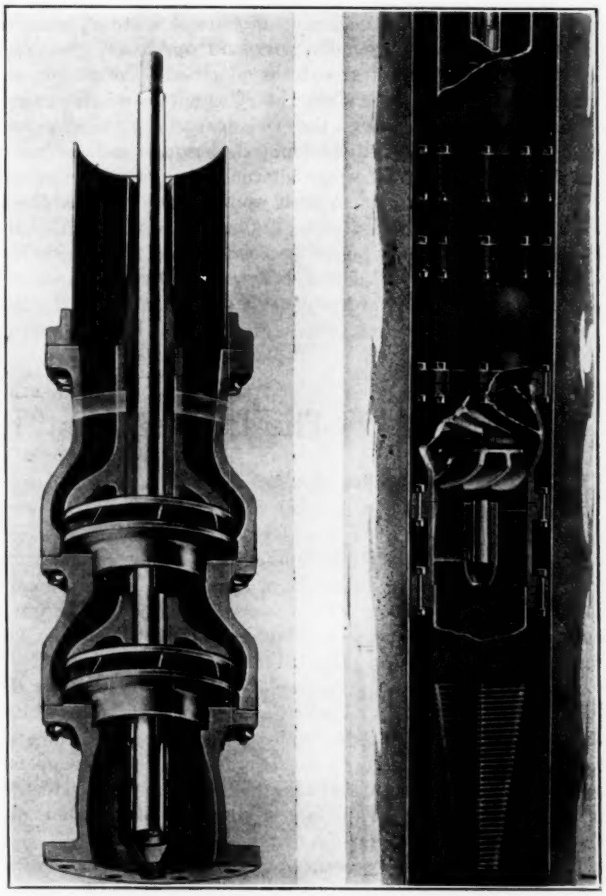
In addition to the economies effected by this type of construction, practically all of the trouble encountered with the older type of head has been eliminated, and many pumps now operate for periods as long as four or five years without attention from the operator except the periodical filling of the lubricators.

Enlarged Field of Application of Modern Deep-Well Turbine Pumps

With the improved mechanical and hydraulic design of the deep-well turbine pump, its potential field of application has been greatly enlarged. Many pumps of this type are now in waterworks service, and many others are used for mine unwatering and construction work where they provide an easy solution of difficult problems. There are at the present time a number of pumps in successful operation with settings in the neighborhood of 500 ft., notable among these being the unit installed by the city of Glendora, Calif., where the bowls are located 476 ft. below the ground surface, and an installation for the Fontana Water Company, which incidentally has the bowls set 500 ft. below the ground surface, while many are in operation with capacities up to 5000 gal. per min. from which excellent results are being obtained.

Going to the other extreme, a number of manufacturers are building pumps of the deep-well turbine type for pressure-system work, these pumps being designed for installation in wells as small as 4 in. in diameter and for capacities as low as from 40 to 50 gal. per min. These smaller units operate at speeds up to 3450 r.p.m. and give excellent service.

While the design and operating characteristics of the deep-well turbine pumps have been very greatly improved, full advantage of this improvement unfortunately is not always taken in the application of a given size or type of unit to a particular service. It is of course quite obvious that if the manufacturer knows definitely the conditions under which a pump will be required to operate in a contemplated service he can then choose the unit which will best fulfil the stated conditions. In far too many applications insufficient information regarding the characteristics



(*Left*) Two-Stage Bowl Assembly Employing Centrifugal-Type Impeller Having a Steep Head-Capacity Characteristic. (*Right*) Bowl Assembly With Impeller of Mixed-Flow Type for Obtaining a Flat Horsepower Characteristic

of the well is available, and consequently a great many pumps in operation today are working at a point on the performance curve where the full advantage of modern design cannot be secured. The efforts of the entire industry are now directed toward a campaign of education which will convince the users of this type of equipment of the advantages of a careful and thorough well test before the specifications covering the equipment are issued. There is considerable opposition to this test on the part of many small users, because of the expense involved. However, it is a fact that in most cases where the well is tested before the pump is purchased and a pump chosen which has a characteristic conforming closely to the characteristic of the well, the resulting saving will pay for the cost of the well test many times over.

In common with many industries whose products are distributed over a wide range of small purchasers and in which competition is keen, a condition was gradually created between the manufacturer and user of deep-well turbine pumps which resulted a few years ago in a fairly general feeling of mistrust. While it is difficult to determine accurately just how a situation of this type arises and who is responsible, it is probably true that the condition is brought about by the purchaser's endeavoring to secure the cheapest equipment for the service involved, and in so doing pitting one manufacturer against another. It is also true that in many cases machinery salesmen in an endeavor to secure an order will commit their principals to operating performances which are impossible of fulfilment, the combination resulting in an exceedingly unfortunate state of mind on the part of both the manufacturer and purchaser.

About two years ago, through the efforts of a group composed of representatives of the California Committee on Relation of Electricity to Agriculture, the University of California, the pump manufacturers, and the pump dealers, a standard form of purchase agreement for deep-well turbine pumps was devised. This agreement, which has been approved by the California Farm Bureau Federation, the University of California, the Western Irrigation Equipment Association, and the Pacific Hydraulic Engineering Association, is now in use by a large number of manufacturers to afford protection to both buyer and seller, and provides a means of definitely setting forth the operating characteristics of the unit which is to be installed, the sales price, terms of payment, and, if the purchaser so desires, a means of checking the performance with a test. The use of this agreement in the purchase of deep-well turbine pumps during the two years that it has been in effect has reduced to a minimum the number of misunderstandings between purchaser and manufacturer and has been a great help to the industry in general; and as a result of the successful application of the standard form of purchase agreement on deep-well turbine pumps, a similar agreement is now being compiled covering the drilling of irrigation wells. Inasmuch as the well-drilling industry is closely allied with the manufacture and installation of pumps, it is believed that when the purchase agreement for wells is completed and its use becomes universal the relation between the purchaser, well driller, and manufacturer will be improved to an extent never before believed possible.

In conclusion, it may be stated that the research and experimental work which has resulted in the improvements made in the design of deep-well turbine pumping equipment during the past ten years are still being carried on throughout the industry, and accordingly a still further improvement during the next ten years may reasonably be expected.

The author desires to acknowledge the assistance of Messrs. W. N. Beadle, manager of the Byron Jackson Company, and W. M. Mason, vice-president of the Layne & Bowler Corporation, in the preparation of the paper.

The International Relationship of Minerals

THIS is an address delivered before the British Association for the Advancement of Science by Sir Thos. Holland, the president. Its purpose is to indicate how the distribution of natural sources of key minerals affects the relations between various nations. From the time that alloys of steel acquired an importance no nation could be self-contained, and a new era of international dependence was inaugurated, although this was not realized by public leaders until 1914.

How little this situation was realized is demonstrated by the fact that the tungsten ore deposits of South Burma were worked almost entirely by British companies. The whole of the mineral, however, went to Germany for the manufacture of tungsten metal, and Sheffield, which occupied a leading place in the production of high-speed steel, then the largest consumer of tungsten, was dependent on Germany for the metal.

In the first place, it becomes obvious that no single country, not even the United States, is self-contained, whether for the requirements of peace or for the necessities of war. Not even the more scattered sections of the earth that are politically united to form the British Empire contain the full variety of those minerals that are the essential raw materials of our established activities. Between them, these two—the British Empire and the United States—produce over two-thirds of the 2000 million tons of minerals that the world now consumes annually. Each of them has more than it wants of some minerals, but, in order to obtain its own requirements, at economic rates, each finds it necessary to sell its surplus output to other nations. Each produces less than it wants of some minerals, and so must obtain supplies from other nations to keep its industries alive. Each of them is practically devoid of a few but not always the same minerals, which, though relatively small in quantity, are none the less essential links in the chain of industrial operations.

Even if these two could "pool" their resources they would still be compelled to obtain from other nations the residual few. For it is important to remember that, unlike organic substances, it is not possible to make synthetic metals, and it will never be; it is not even possible to make artificial substitutes for many essential minerals that are used as such and not merely for their metallic constituents. There is no other mineral and no artificial substance, for instance, that can combine the qualities which give to the mineral mica its position of importance in the arts. There will never be a synthetic mica.

Thus, the international exchange of minerals is an inevitable consequence of our new civilization; and the cry for freedom of movement, for the "open door," and for equal opportunity for development comes into conflict with the unqualified formula of "self-determination." Whatever may have been possible before the industrial revolution, when the mineral industry merely contributed to the simple wants of agriculture, when most national units were self-contained, the formula of "self-determination" has come too late in the world's history to do good without a more consequent amount of harm. We cannot even live now without the free interchange of our minerals for those of other nations; in the name of civilization we dare not go to war.

Primitive workers in various lands have opened up to relatively shallow depths rich but small deposits of ore, and in the Eastern countries especially, where forms of civilization extend far back into history, the numerous and widespread "old workings" have given rise to travelers' impressions of great mineral wealth. But low-grade deposits that the ancient miner could not utilize are now opened up by mechanical methods on a large scale; and, on the other hand, what satisfied the primitive metallurgist in abundance would be of little use to the modern furnace.

It would have been a shock to the members of the British Association if, before the war, political problems had been discussed from the president's chair, but the results of science and technology now limit the effect of natural ambitions and therefore dominate the international political atmosphere for good or evil. (Abstracted through *The Chemical Age*, vol. 21, no. 527, Aug. 3, 1929, pp. 9-11 of the monthly metallurgical section, *g*)

From the Master Cabinetmakers to Woodworking Machinery

The Medieval Carpenter-Furniture Maker—The English Master Cabinetmakers—Early Hand Tools—The New Era—Bentham's Planer—The Newberry Bandsaw

By J. D. Wallace[1] and Margaret S. Wallace,[2] Chicago, Ill.

THE history of woodworking machinery from earliest times until today may be likened to a great and complex drama of interwoven comedy and tragedy. The action opens when the first man uses a block of wood for a seat; the plot and subplots develop steadily through the Middle Ages, reaching a climax in the great industrial revolution of the eighteenth century; the conclusion is modern industrialism with its power machinery and mass production. The tragic moment—if one wishes to call it that—is the passing of the great English cabinetmakers.

Until about 1716 in England most work was purely manual. Machines were not used because they had not been invented. Mass production, industrialism, and capitalistic organization were unknown. The prevalent form of industrial organization was the guild, wherein master worked with his men; and men, in due course of time, all became masters.

The Master Cabinetmakers

Until the time of Chippendale, furniture took its style name from its period—such as Tudor, or Jacobean, and not from its maker. Thomas Chippendale, who was born in the early seventeen hundreds and died in 1779, was the first cabinetmaker to stamp his own personality upon his products. The man had a good eye for advertising and salesmanship as well as talent in furniture making. His book "The Gentleman & Cabinet Makers Directory" was the earliest of its kind. Chippendale's special skill was in the making of chairs, though he possessed astonishing versatility. Carving was his favorite form of decoration, and he indulged this taste lavishly on his furniture—much of it mahogany, an admirable medium for this style of ornamentation. (See Fig. 1.)

The four brothers Adam (the Adelphi), outstanding figures from 1762 to 1792, were architects as well as designers of furniture, and both houses and furniture designed by them showed the same simple, classic influence. Two of the four brothers, Robert and James, really made the family name famous in the furniture trade. They were designers, not craftsmen, and their commissions were executed by Chippendale, Heppelwhite, and Sheraton, as well as by workmen of their own employment. The Adam style was a strictly classical one, employing straight lines, restrained ornament, and beautiful painting and inlaying of rare woods. This was in distinct contrast to the florid, curvilinear styles of previous years. Being architects, the brothers did their finest work on cabinets, and it is for these that they are best noted. (See Fig. 3.)

A sort of halfway mark between the brothers Adam and Sheraton is found in Heppelwhite, whose designs, outlasting his life, were most popular from 1765 to 1769. Heppelwhite used curved lines more than the brothers Adam, being much influenced by the French Louis-Seize style. He employed light woods, and was partial to painting and inlaying. His articles, particularly the chairs, showed, in spite of their lightness, the sturdier build typical of English furniture. (See Fig. 2.) Heppelwhite's styles were given much notice by the posthumous publication of his two books of design: "The Cabinet Maker and Upholsterer's Guide" and "The Cabinet Makers' London Book of Prices and Designs of Cabinet Work."

Fig. 1 Chair by Chippendale, Mahogany, in the Gothic Manner
(Courtesy of Furniture Publishing Corporation, Jamestown, N. Y.)

Fig. 2 Chair by Heppelwhite, With Characteristic Back Shape
(Courtesy of Furniture Publishing Corporation Jamestown, N. Y.)

Furniture designers of the last decade of the eighteenth century were dominated and guided by Thomas Sheraton. He was more a designer than a craftsman, though he was skilled in all the details of furniture making. Many of his designs reflect the style of French furniture, particularly that of the Louis-Seize type. Sheraton employed straight lines, graceful contours, and much inlaying and marqueterie. (See Fig. 4.) He was a classicist, but also foreshadowed the modern employment of geometrical designs for ornament. His ingenuity in the invention of double-purpose furniture is very interesting. Commodes and wash-hand stands, in a period when modern conveniences were lacking, were developed into pieces of furniture—"used in genteel bedrooms, and were sometimes finished in a style a little elevated above their use," as Sheraton puts it. A desk is cleverly contrived so that a drawing board on it may be raised and lowered, and tilted to any angle; a Pembroke table (see Fig. 5) is fitted with a shelf ladder folding into its drawer. These and other pieces of furniture make interesting his remarkable book of designs, "The Cabinet Maker and Uphlosterer's Drawing Book—the Whole

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Contributed by the Wood Industries Division for presentation at the Annual Meeting, New York, December 2 to 6, 1929, of The American Society of Mechanical Engineers. Abridged.

FIG. 3 ADAM SIDEBOARD WITH PEDESTALS AND KNIFE URNS, EXECUTED IN MAHOGANY, SHOWS CLASSIC STYLE, STRAIGHT LINES, AND RESTRAINED ORNAMENTATION
(By courtesy of Westing, Evans, and Egmore, Philadelphia, Pa.)

FIG. 4 SHERATON CARD TABLE, MAHOGANY INLAID WITH SATINWOOD
(By courtesy of Furniture Publishing Corporation.)

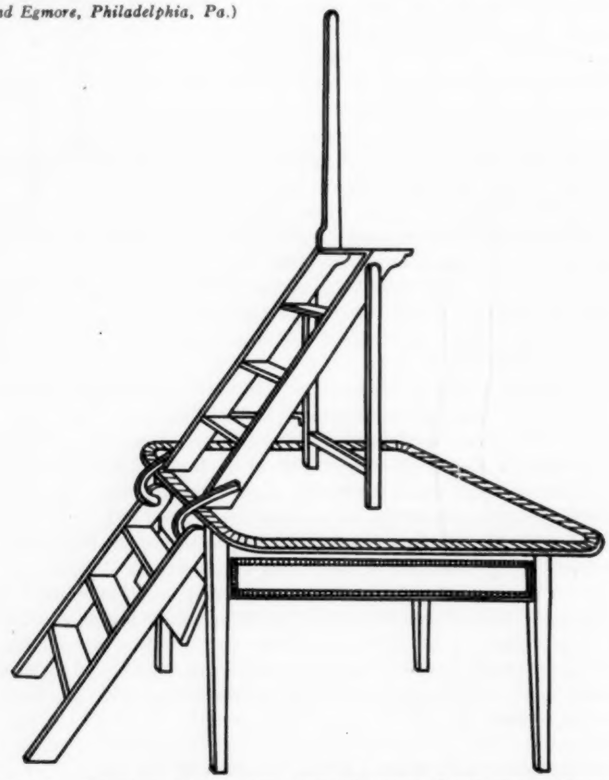

FIG. 5 PEMBROKE TABLE AND SHELF LADDER, REPRODUCED FROM SHERATON'S "THE CABINET MAKER AND UPHOLSTERER'S DRAWING BOOK"
(Illustrates ingenious double-purpose design for which Sheraton was noted.)

Embellished with 122 Elegant Copper Plates." It may be said that furniture-design books of that century were all, excepting that of the brothers Adam, the work of practical cabinetmakers.

Early Hand Tools

Tools employed in furniture making were hand tools. Under Chippendale the beautiful decoration of chair backs and legs was done with the carver's chisel. During the Heppelwhite period, grooving and reeding planes came into use. The legs of chairs, if not left quite plain and square, or simply turned, were ornamented by the use of these planes. Sheraton, in his drawing book, mentions the center bit, the sash saw, and the plane. He was an experienced craftsman, and here and there in his book inserts bits of helpful information about tools to be improvised. Thus he gives instructions, in making a door, ". . . .for working the astragals (molding or beading) on the edge; which may easily be done, by forming a neat astragal in a piece of soft steel, and fixing it in a notched piece of wood and then work it as a gauge. ." Typical hand tools available during that period are illustrated in Figs. 6–9, reproduced by courtesy of the Victoria and Albert Museum of London. Tools in this collection, while dated as far back as 1694, are not the earliest examples known, but are representative of those in general use during the eighteenth century.

The New Era

All this time, until the end of the eighteenth century, the action of the drama had been rising to a climax which came with the industrial revolution, when inventions of modern machinery were made in rapid succession.

The tool, removed from the hand of the craftsman and guided

FIG. 8 (*Top*) MOLDING PLANE, BEECHWOOD, CARVED WITH SCROLLS; ENGLISH, DATED 1734; LENGTH, $7^1/_2$ IN.; WIDTH, $2^3/_4$ IN. (*Middle*) SKEW-MOUTH FILLISTER PLANE, BEECHWOOD, CARVED WITH SCROLLS; ENGLISH, DATED 1744; LENGTH, $7^3/_4$ IN.; WIDTH, $2^5/_8$ IN. (*Bottom*) SKEW-MOUTH REBATE PLANE, BEECHWOOD, CARVED WITH SCROLLS, ENGLISH, DATED 1766; LENGTH $7^7/_8$ IN.; WIDTH, $2^5/_8$ IN.

(Reproduced by permission of Albert and Victoria Museum, London.)

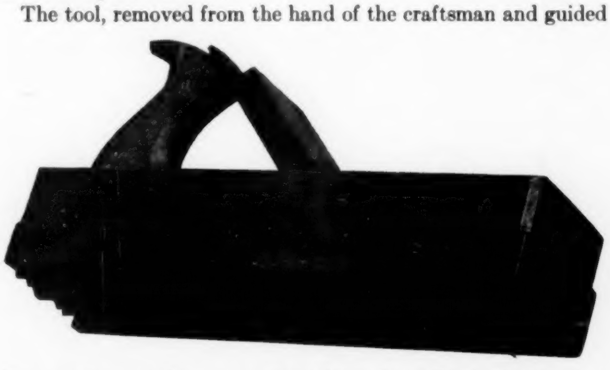

FIG. 6 MOLDING PLANE OF WOOD WITH IRON BLOCK STAMPED ON ONE END, MICHAEL SAXBY AND F. C. 1756; LENGTH, 1 FT.; HEIGHT, $6^1/_4$ IN.

FIG. 7 JOINTER'S PLANE, 2 FT. 7 IN. LONG, 3 IN. WIDE; BEECHWOOD, WITH CARVED HANDLES; ENGLISH, DATED 1771

instead by some mechanism having a prearranged motion, ceased to be a tool and became a machine. The modern machine is threefold; it consists of the motor mechanism, the transmitting mechanism, and the tool or working element. Such machinery makes possible the use of greater motive force, and greater exactitude in its application.

These developments would seem to offer great advantages, and although one would not expect an ignorant people fully to appreciate them, it is rather surprising to know that in 1663, when a Dutchman erected the first sawmill near London, it was attacked by a mob and had to be abandoned because of public disapproval. Even as late as 1768 another sawmill, started by

James Stansfield, was attacked and caused to be abandoned; though in other parts of England mills were started and run successfully by Stansfield with the aid of the government. These were all wind-power mills with jigsaws, until in the year 1777 one Samuel Miller patented a sawmill using a circular blade.

Up to that time inventive progress in woodworking machinery was comparatively slow, but at the end of the eighteenth century there arose a remarkable man, Sir Samuel Bentham, who within

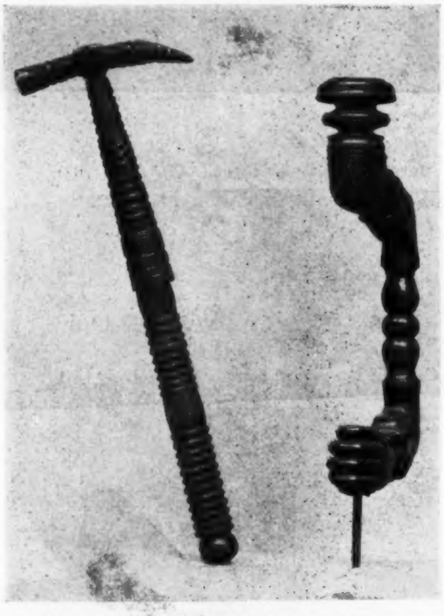

Fig. 9 Early English Hand Tools

(Left: Hammer head and shaft, signed Leander Green, English, dated 1694. Right: Handbrace of turned and carved boxwood, English (?), dated 1642, length 9¾ in., diameter of head 1⅝ in.)

(Reproduced by permission of Albert and Victoria Museum, London, England.)

a few years invented and patented almost every known variety of woodworking machine.

His father was wealthy and sent him to Westminster School in London, where he completed his studies in 1770. Thereafter he was apprenticed for seven years to the master shipwright of Woolwich dockyard. His apprenticeship served, he spent eighteen months visiting other dockyards, and in 1779 was sent by his government to tour the northern part of Europe, examining the shipbuilding and other arts. In Russia he stayed for some time as a naval engineer, holding, in 1785, the rank of colonel in the Russian army. Here he devised a plan for the central inspection of his Russian shipwrights, a method afterward suggested as a means of supervising convicts. Shortly after 1779, while still on his tour, Bentham invented the first planing machine for wood that really could be called an organized operating machine. The one patented in England in 1776, by Hatton (see Fig. 10), is almost too crude to be considered.

In 1791 Bentham returned to England, where later he became brigadier-general and inspector-general of the naval works of England. Here he found his brother, Jeremy Bentham (the famous writer on political economy) in charge of a number of industrial prisons, containing ignorant convicts who must nevertheless be put to profitable work. Apparently they were incapable of doing handwork in wood, but perhaps they might be able to run a simple machine; thus reasoned Sir Samuel. He therefore devised a large number of woodworking machines for use in these prisons. The residence of Jeremy, at Queen's Square Place, Westminster (now a part of London), was in 1791 made into the first manufactory of woodcutting machines. In the Benthams' factory were made machines for planing, molding, rebating, grooving, mortising, sawing—in coarse and fine woods, in curved, winding, and transverse directions—and shaping wood in all sorts of complicated forms. They even made a machine which could make a highly finished window sash, and another which could make an ornamental carriage wheel, both items finished except for assembling.

The Bentham Planer

Sir Samuel's inventive genius was inexhaustible. In 1791 he issued his first recorded patent, for a planing machine, which was in principle an enormous handplane with elaborate mechanisms for passing it forward and back along the stock. Bentham described the essence of the invention as a "method of planing divesting the operation of skill previously necessary, and a reduction of brute force employed." No drawings are included with Bentham's inventions for his stated reason that "they tend to confine the attention to a particular mode, whereas words cover the construction in a general way." It is interesting to note that the British Patent Office of that day sanctioned the omission of drawings.

In the Bentham planer the bit or knife is as wide as the stock to be planed; the board is laid on a bench longer than itself; "cheeks" extend down over the sides of the knives; and the ends of the plane are rounded to rise up on the board. As the cut is

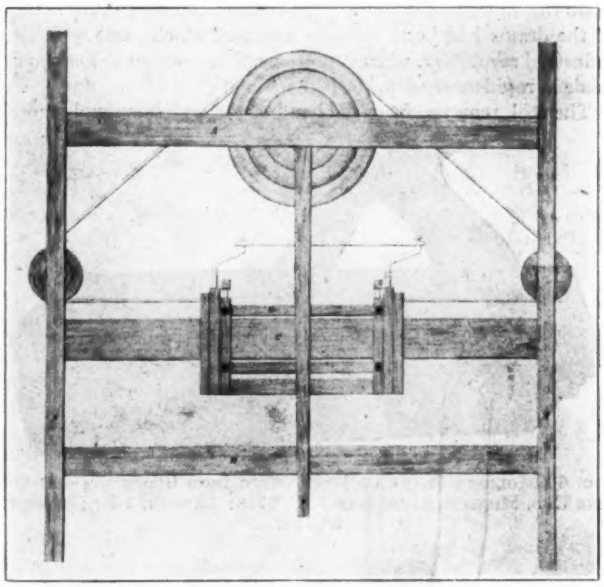

Fig. 10 Hatton's Planer

(The first step away from the hand plane. Drawing and description copied from original English Patent No. 1125, issued in 1776. Referring to letters on diagram of planer: *A* is the frame with pulleys and wheels; B, the bench on which wood to be planed or fluted is laid; *C*, the bar which keeps the sliding frame in a line; *D*, the sliding frame with closing screws and stock screws; *E*, the stock in which are fixed the several tools for planing and fluting; *F*, the pendulum or handle for moving the sliding stock and tools. By moving *F* backward and forward to the outlines *A*, the work is performed by the tools lodged in *E*, the wood to be planed or fluted lying on *B*.)

started, a movable weight is pressed down on the front end of the plane, being shifted to the rear as the stroke is finished, while means are provided to raise the knife on the return stroke. A compound bench to support warped boards at the middle and two sides, and multiple bits to take successive cuts with one pass are proposed. The suggested motive power is "wind, water, steam, or animal strength."

This planer, merely a development of Hatton's idea, was hardly prophetic of Bentham's following inventions, comprising British

Patent No. 1951, issued in the year 1793. Few men have had the honor to cover their chosen industry so thoroughly with patents as did Bentham with this single application. In one all-inclusive document of eleven sections he originated, with broad claims, practically every woodworking machine and process that is in use today.

The Newberry Bandsaw

Thus in one stroke did Bentham blanket the woodworking industries, leaving unmentioned only the scroll bandsaw, which was invented in 1808 by another Englishman, William Newberry. (See Fig. 11.) It is worthy of note, however, that the bandsaw did not come into general use for nearly fifty years, when in 1855 M. Perin, of Paris, France, exhibited at the French International Exhibition a bandsaw with greatly improved blades, capable of delivering a reasonable amount of service before breakage.

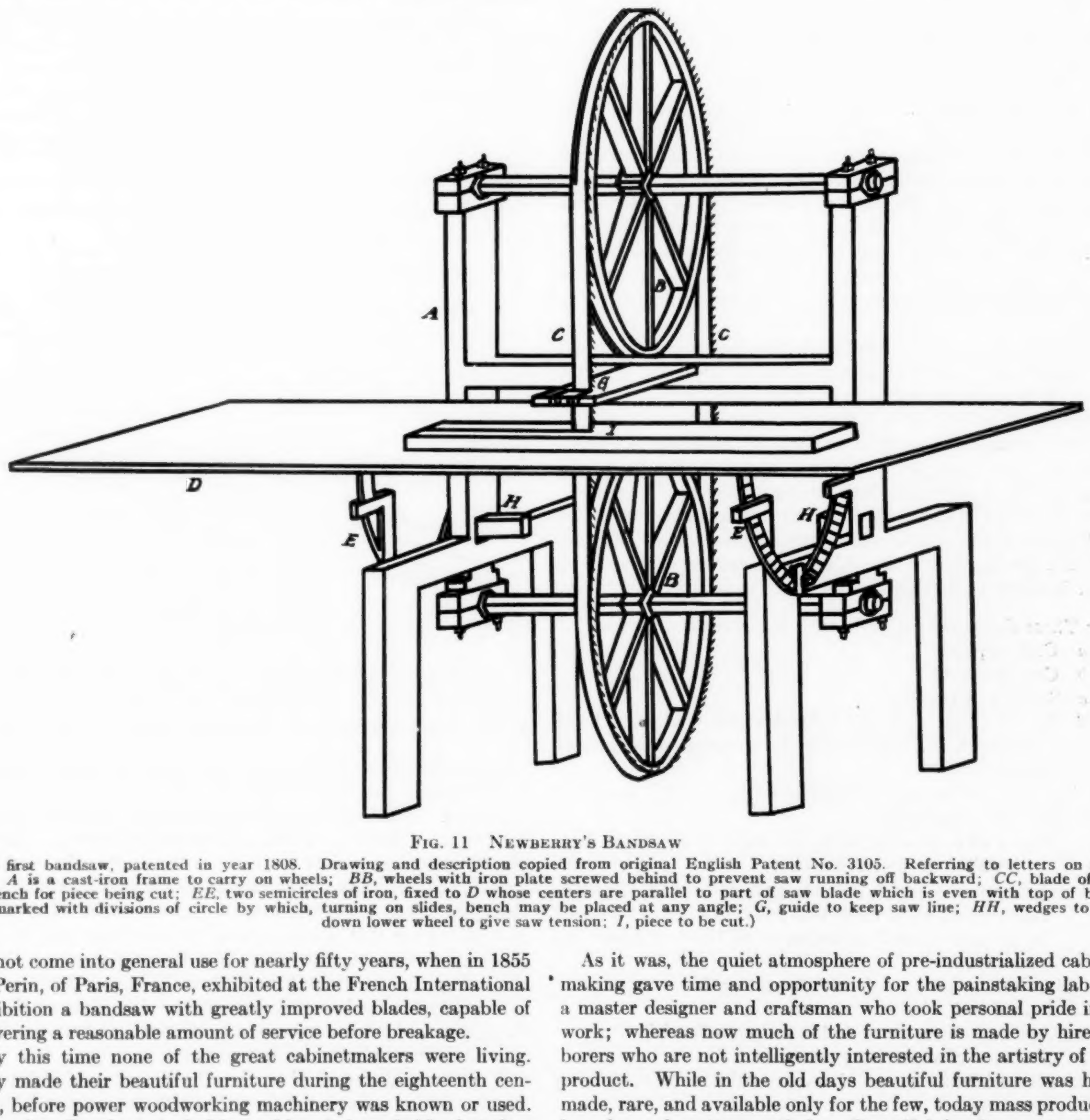

Fig. 11 Newberry's Bandsaw

(The first bandsaw, patented in year 1808. Drawing and description copied from original English Patent No. 3105. Referring to letters on drawing: *A* is a cast-iron frame to carry on wheels; *BB*, wheels with iron plate screwed behind to prevent saw running off backward; *CC*, blade of saw; *D*, bench for piece being cut; *EE*, two semicircles of iron, fixed to *D* whose centers are parallel to part of saw blade which is even with top of bench, one marked with divisions of circle by which, turning on slides, bench may be placed at any angle; *G*, guide to keep saw line; *HH*, wedges to force down lower wheel to give saw tension; *I*, piece to be cut.)

By this time none of the great cabinetmakers were living. They made their beautiful furniture during the eighteenth century, before power woodworking machinery was known or used. Even when Bentham made his machines it is probable that they were not much used by cabinetmakers, for they were rough, heavy machines, more suitable for cutting ship timbers than fine pieces of furniture. It must be remembered that Sir Samuel Bentham was a naval engineer, not a cabinetmaker. There is no record that any of the great cabinetmakers ever invented or made power woodworking machinery, though many of them, for example, Chippendale and Heppelwhite, were practical craftsmen.

During the seventeenth century the use of hand woodworking tools had reached the zenith of development. A long background of experience enabled men to wield their hand tools with the skill of the artist, and to produce works of art in wood. The care expended on each piece was necessarily great, because it was done all by hand. Each article was executed as an individual work, not as one of a thousand similar pieces. If the cabinetmakers had employed the crude machines at their disposal toward the end of the century they probably would have produced crude, unbeautiful furniture, for men were not yet masters of the new machines.

As it was, the quiet atmosphere of pre-industrialized cabinetmaking gave time and opportunity for the painstaking labor of a master designer and craftsman who took personal pride in his work; whereas now much of the furniture is made by hired laborers who are not intelligently interested in the artistry of their product. While in the old days beautiful furniture was handmade, rare, and available only for the few, today mass production has changed matters entirely. Beautiful furniture now is machine made—with greater precision, uniformity, and strength than the best of the old cabinetmakers could attain; it is abundant, and available to the great majority of people. Of the two eras, the old and the new, there are few of this generation who will hesitate, even though they may regret the passing of the old cabinetmakers, to choose modern industrial methods as best.

Factors Affecting Power Cost

A Consideration of Various Factors Having to Do With Investment, With the Degree of Utilization of Investment, and With Operating Costs

By C. F. HIRSHFELD,[1] DETROIT, MICH.

DURING the past decade or two the public has become "power conscious." That is, the public has begun to appreciate the significance of an adequate and reliable power supply both with respect to its industrial and its social life. This development has brought about a very real interest in the cost of power, and there have appeared many leaders who have proposed this, that, and the other method of producing power more cheaply than is now generally the case.

As frequently happens, these self-appointed leaders are, in many cases, imperfectly prepared for the work that they have undertaken, and as a consequence their teachings are sometimes not only erroneous but harmful. One frequent source of confusion and error lies in the meaning that is given to Power Cost. Most people conceive of it as the cost of generation, whereas in any real case this is only a part of the cost that must be met by any consumer. In many classes of service the cost of generation is a remarkably small fraction of the actual cost of rendering the service.

Since I am to speak on factors affecting power cost, it would be well to define just what cost it is that I am going to speak about. I have assumed that it was the intention that I should confine my remarks to those things affecting the cost of power as prepared for shipment to the consumer, not as delivered to him. Moreover, I propose to confine my considerations to a still narrower field, namely, to fuel-burning stations. Please note, therefore, that what I am about to say covers only a part of the total cost of power as delivered to any consumer, large or small.

Within the limitations that I have just expressed, the cost of power is affected primarily by the following factors:

1 Those things having to do with Investment; principally
- *a* Cost of plant
- *b* Cost of money
- *c* Severity of taxation
- *d* Extent of provision for balancing depreciation and obsolescence, i.e., maintaining the integrity of the investment.

2 Those things having to do with the Degree of Utilization of the Investment; principally
- *a* Extent of reserve capacity, i.e., ratio of maximum load to installed maximum capacity
- *b* Plant capacity factor, indicating the ratio of the kilowatt-hours produced to those that could have been produced in the same time if operating at all times at maximum capacity.

3 Those things having to do with Operating Costs; principally
- *a* Cost of fuel
- *b* Cost and character of skilled and unskilled labor
- *c* Character of supervisory personnel
- *d* Character and extent of water available for condensing purposes
- *e* Character of feedwater available
- *f* Character of equipment and the way in which it is assembled to form a complete plant
- *g* Character of maintenance
- *h* Character of load with respect to steadiness
- *i* Load factor by day, week, month, and year, and
- *j* The extent to which live reserve is carried.

It will be recognized that this is a very formidable list, and it is obvious that one who is not completely familiar with this subject might easily overlook important items affecting power cost at the outgoing lines. In fact, there are very few individuals who are not directly connected with modern power generation who can properly recognize and evaluate all the factors in this problem.

Time will not permit a detailed consideration of all items listed above, but I shall endeavor to indicate a few high spots with respect to each.

Those Things Having to Do With Investment

It is practically impossible to state what one might call an average cost for a given type of plant. This results from the fact

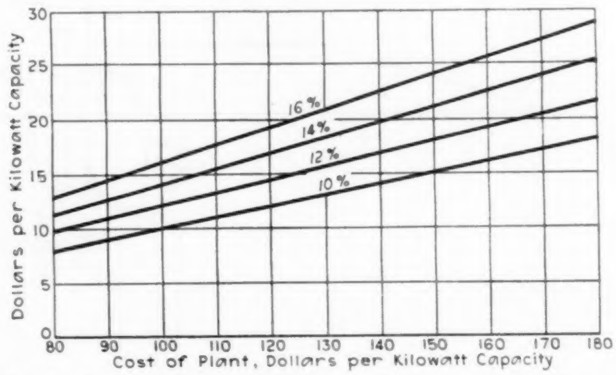

Fig. 1 Fixed Charges per Kilowatt-Year at Various Rates

that practically no two plants are built under the same conditions with respect to terrain, character of soil, size and type of equipment, type of design, type of labor available, and so on through an almost endless list. A reasonably average figure for plants in the 400-lb.-pressure class would be in the neighborhood of \$100 per kw. installed capacity, but the figure varies in fact from something like \$80 to something like \$130 or even more. The present indications are that a comparable 1400-lb. plant can be built at a cost of something like 10 to 15 per cent in excess of that of a 400-lb. plant, or, say, \$110 to \$115 on the basis of \$100 per unit of capacity for the lower-pressure plant. It is obvious that the range in cost of one general type may be much greater than the indicated difference between the two types.

The effect of cost of plant may be shown graphically as in Fig. 1. The curves of that figure indicate the number of dollars which must be earned annually by each kilowatt of installed capacity at different plant investments and at different total percentages for those cost items that may be considered proportional to investment. Under normal conditions the percentage required to cover such items will usually be 12 to 14, depending upon the average cost of money, the severity of taxation, the estimated useful life, etc. With a plant cost of \$100 and with the percent-

[1] Chief, Research Department, Detroit Edison Co. Mem. A.S.M.E. Address delivered at the S.P.E.E. Summer School for Teachers of Mechanical Engineering, held at Purdue University, Lafayette, Ind., June 27 to July 18, 1929.

age at 12 it is obvious that each kilowatt of installed capacity will have to earn $12 per year to cover fixed charges.

Some such sum must be earned per year on each hundred dollars of investment to cover such things as interest on the money invested, insurance, taxes, and an allowance of some sort for depreciation and obsolescence. The cost of money is readily ascertainable at any time and place. The same is approximately true for taxes and insurance. The allowance for depreciation of capital assets is in an entirely different category. One can judge somewhat from experience, but at best it is a guess.

It is not so long ago that power-plant equipment was assumed to have a life of at least twenty years and power-plant buildings a life of twenty-five or thirty years. Such values are conservative when one considers only the operating possibility. However, when one considers the operating probability, far different figures frequently present themselves. It is not that the apparatus is worn out but that it is less desirable and useful than before because of size, thermal economy, personnel requirements, location, flexibility, or what not. The graphs of Figs. 2 and 3, which give the histories of outputs of different units in two typical stations, show very well what happens when plants are built serially or units are installed serially. Each unit, in general, reaches a peak of production and then drops off in favor of more modern units. It is obvious that while twenty or more years of use may be assumed as feasible, about five to seven years of heavy-duty life represents a good average if these graphs are typical. And they are typical of a great many actual cases.

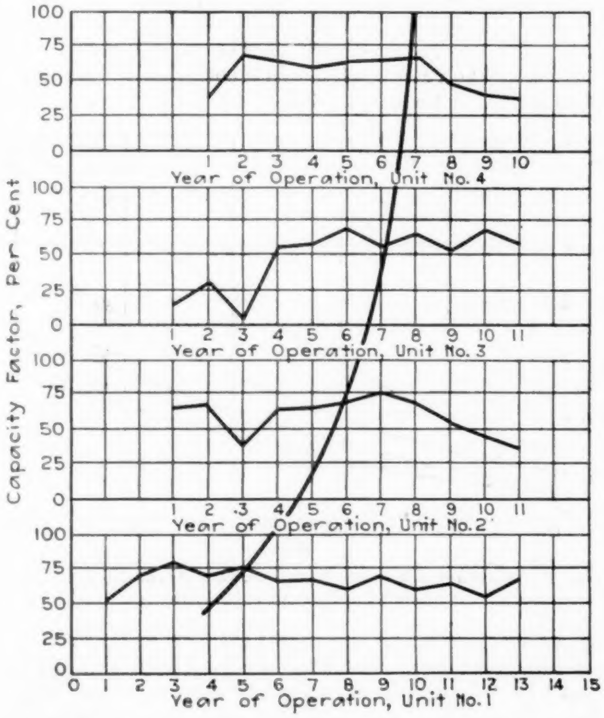

FIG. 2 HISTORY OF OUTPUTS OF DIFFERENT UNITS IN A TYPICAL STATION

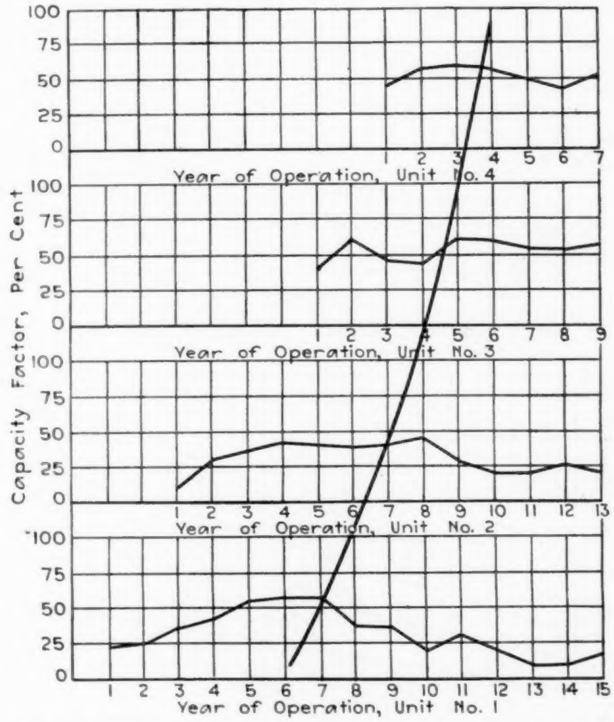

FIG. 3 HISTORY OF OUTPUTS OF DIFFERENT UNITS IN ANOTHER TYPICAL STATION

It is such uncertainties as are indicated by these graphs that make many executives "play safe" when it comes to estimating probable useful as against usable life.

THOSE THINGS HAVING TO DO WITH THE DEGREE OF UTILIZATION OF THE INVESTMENT

If a plant stands all alone as a source of power supply to an industry or to a community, it is obviously necessary that it contain sufficient spare equipment so that continuity of service may be insured *to the required degree.* The last few words are just as important as the preceding part of the sentence. At one extreme is a plant which supplies a load which is very heavy during one or two months of the year and comparatively light during the remaining months. In such a case the conditions of power supply may permit the use of all installed equipment at practically full capacity during the heavy-load period, with all the rest of the year available for overhaul of one unit after another. At the other extreme would be a plant which at all times could lose the greatest conceivable number of units at one time, short of a catastrophe, and still carry its load. Most plants fall between these two extremes. As interconnection of plants and systems occurs, the reserve required per plant decreases and capital is better utilized. Also, as the reliability and ability to continue in use over long periods increase, the percentage of reserve decreases.

In any case, reserve somewhere is necessary, and to the extent required by the needs of the particular system. And the existence of this reserve represents a limitation on the use of investment.

The extent to which the plant investment is utilized is measured roughly by the plant capacity factor. This is the ratio of the kilowatt-hours produced in a given period to the total that could have been produced had the plant operated at full capacity throughout the period. The same factor is sometimes measured by what is known as the "hours of use." The numerical values are much lower than most people realize, even in the cases of heavily loaded plants. This is partly due to overlooking the necessity for reserve capacity and partly to confusion of capacity factor and load factor.

As an example, consider a plant with a total capacity in turbines, boilers, and associated equipment of 300,000 kw. Assume

that such a plant carries a peak load of 250,000 kw. and has an annual load factor of 55 per cent. Such a plant would generate annually 1,204,500,000 kw-hr. Had it worked at maximum capacity throughout the year it would have generated 2,628,000,000, indicating a plant capacity factor of about 46 per cent. Incidentally a plant of this type might easily show daily load factors of over 70 per cent.

Let us see now what the significance of plant capacity factor really is. The graphs of Fig. 1 indicated the amount that must be earned per kilowatt of capacity per year to balance the charges that are proportional to investment. In Fig. 4 are shown at the intersections of the graphs the necessary charges per

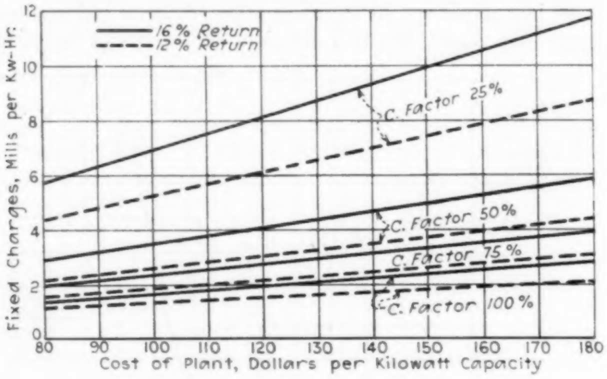

FIG. 4 EFFECT OF CAPACITY FACTOR ON FIXED CHARGES

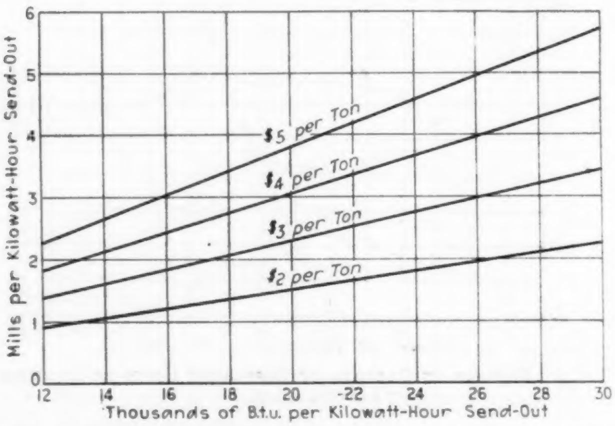

FIG. 5 EFFECT OF COAL PRICES AND PLANT EFFICIENCY ON UNIT FUEL COST

kilowatt-hour sent out at different capacity factors. It is at once obvious that the fixed charges per kilowatt-hour are by no means negligible under the most favorable circumstances, and that the plant capacity factor has a tremendous effect upon these charges. When it is realized that in the average metropolitan system the power-plant investment may fall between one-third and one-half of the total investment, it is obvious that costs proportional to investment represent a fairly high charge against each kilowatt-hour sold.

THOSE THINGS HAVING TO DO WITH OPERATING COSTS

Under this heading in the list as originally presented I put fuel first. Under what one may call normal circumstances the fuel cost is generally much the largest component in this group. The magnitude of this item is indicated by Fig. 5 for an extended range of possibilities. Many of the older plants still consume 25,000 to 30,000 B.t.u. per kw-hr., and the best modern plants running at high load factors generally fall in the neighborhood of 14,000 to 15,000. It will be observed that with $3 or $4 coal and a very modern plant at high load factor the cost for fuel alone may be expected to run in the neighborhood of 0.2 cent.

There has been much spoken and written on the subject of mine-mouth generation, and many people are convinced that it is far better to burn the coal at the mine mouth and transmit the power to centers of consumption than it is to transport the coal to such centers and generate the power locally. For example, it is not at all difficult to find cases where coal is purchased at the mine at from $0.90 to $1.25 and then transported at a cost of $2.50 to $3 for the purpose of local generation. With a modern plant burning 1000 or more tons of coal per day it is obvious that the freight bill is a very sizable item.

In such matters as this it is not possible to generalize; each case must really be considered separately. However, it seems desirable to point out a few facts to show the magnitude of certain factors that are sometimes overlooked or underestimated.

We shall take a case in which coal is purchased at the mine for $1.25 per ton and costs $4 delivered and ready to put into the

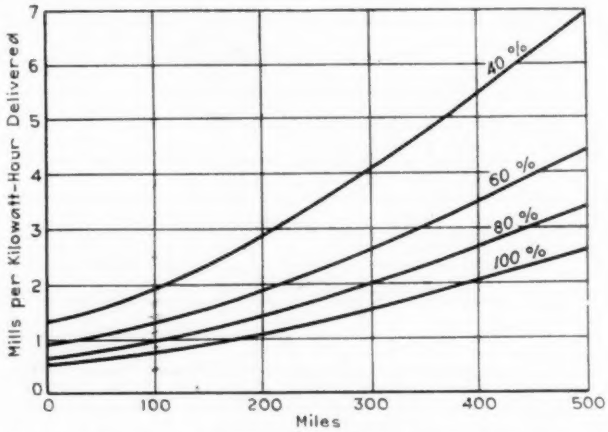

FIG. 6 TRANSMISSION COSTS BASED ON ONE SPARE LINE IN FOUR. LOAD FACTORS AS INDICATED

plant bunkers. That is, the freight charge is $2.75. We shall also assume a modern plant which sends out a kilowatt-hour for each 1.1 lb. of coal received. The total cost of coal used to produce a kilowatt-hour is then 2.2 mills, made up of approximately 0.69 mill for mine price and 1.51 mills for freight.

If we assume an equally efficient plant at the mine mouth and the cost of coal the same as above for mine-mouth conditions, we could then save the 1.51 mills expended for freight with local generation.

Of course if we generated power at the mine mouth and wanted to use it a few hundred miles away we should have to transmit it. And as we are talking about units of large size, such as 150,000 to 300,000 kw., we should have to have an adequate set of transmission lines with step-up and step-down transformer stations at the ends, the necessary condensers, and intermediate switching stations. We should have to pay fixed charges and operating expenses on this transmission equipment.

There are given in Fig. 6 certain graphs which show how much such transmission may cost. It is assumed that four lines are constructed where three are necessary for actual transmission, that is, we assume one spare out of four. This is none too generous an allowance where an important center is dependent upon long transmission lines.

For conditions such as those assumed here the annual load factor would probably lie between 40 and 60 per cent and the distance would be between 200 and 400 miles. It is immediately

obvious that the transmission cost is at least of the same order of magnitude as is the freight charge on the fuel; in fact, in such a case as that assumed it would almost certainly be greater.

When the great dependence of modern social and economic life on an adequate and dependable power supply is realized, it is almost obvious that a large metropolitan district could hardly afford to depend upon the uncertainties of long-distance transmission unless the costs were very greatly in favor of that method.

Another aspect of the fuel cost is interesting. It frequently happens that low-grade coal can be purchased quite a bit cheaper at the mine than can high-grade coal. But, if the freight charge is heavy, it will generally be found profitable to pay for the more expensive coal so as to pay freight on the least quantity of inert material such as ash and water.

Thus, if we take again the figure for freight used above, namely, $2.75 per ton, and assume that we can buy 13,500-B.t.u. coal at the mine for $1.25 per ton, we can construct a chart indicating the price at which we can just afford to buy inferior coal and still receive as many B.t.u. per dollar expended by the time the coal is delivered. Such a chart is shown in Fig. 7. But this is not the whole story. Storage- and handling-equipment investment and operating cost are both increased on the basis of a given number of B.t.u. to be stored and handled. Also the efficiency of utilization in a given station frequently decreases as the B.t.u. per pound of coal decreases. And further, the lower-B.t.u. coal frequently carries the greater quantity of ash, which must be later disposed of.

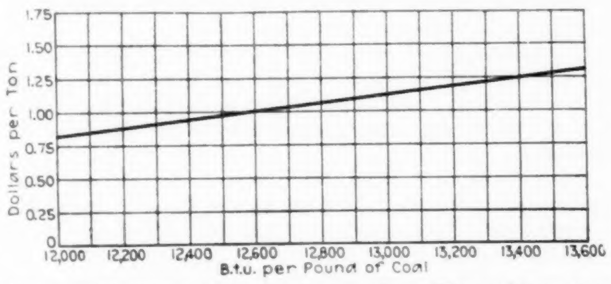

FIG. 7 EQUIVALENT MINE PRICES OF COAL WHICH MAKE DELIVERED PRICES B.T.U. THE SAME FOR ALL COALS ON CURVE

The effect of the wage of skilled and unskilled labor upon the cost of power is frequently underestimated. It may be studied conveniently with the aid of Fig. 8. At the present time the older plants, say, plants 10 to 15 years old, will generally show a production of 300 to 500 kw-hr. per man-hour, while very modern plants operating at a good load factor may yield 1500 to 3000 kw-hr. per man-hour. Much depends upon the design of plant, sizes of units, and the character of the load.

The total of all skilled and unskilled wages may obviously vary very widely, and it is practically impossible to give mean figures per kilowatt-hour or as a percentage of total production cost.

The character of labor is in general far more important than the hourly wage paid. It is easily possible for power-plant labor to vary the fuel consumption of a power plant by 10 to 20 per cent, which in many cases will represent a variation in production cost per kilowatt-hour of more than the total wage paid. Obviously it is good policy to pay that wage required to obtain quality in the personnel of the plant. But it should be noted that power-plant employment is, in general, not seasonal, so that a wage competitive with seasonal industries need not be a wage greater than, or ever equal to, the hourly wages paid workers in the seasonal industries.

The *cost* of supervision in plants of modern size is insignificantly small. The *character* of supervision is all-important. The supervisory organization must be many sided since it has to handle matters of radically different sorts. It must naturally have a complete understanding of the theory underlying the power-plant design so that full advantage can be taken of design possibilities. It must have a complete knowledge of practical operation so that emergencies can be met promptly, so that difficulties can be anticipated and, if possible, prevented, and so that the cheapest effective methods for doing all things may be adopted. The supervisory organization must also have the mental training and attitude required for the study of records, the reasoning from such study, and the devising of methods which take advantage of the results of such studies. And finally, but by no means least, this part of the organization must be marvelously capable in the handling of men so that it not only maintains a smooth-running organization but one that is continuously enthusiastic. The maintenance of good plant performance requires the utmost in the way of painstaking observation and action.

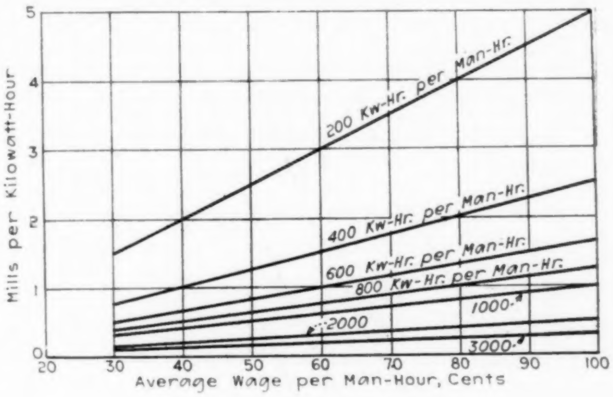

FIG. 8 OPERATING-LABOR COSTS

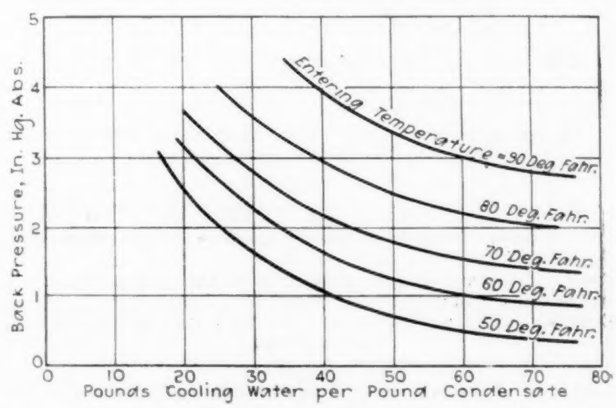

FIG. 9 CHARACTERISTICS OF A SURFACE CONDENSER. COOLING-WATER TEMPERATURES AS INDICATED

We come now to a more concrete consideration, namely, the significance of an adequate supply of good circulating water. The consideration of adequacy is perhaps the simplest and will be treated first.

It is well known that the steam turbine is particularly responsive to reduction of back pressure. Some of the characteristics of surface condensers, which are used almost exclusively in large and small turbine plants, are not so well known. One important characteristic of an average type of surface condenser is shown in Fig. 9. From such a diagram and a curve showing the effect of vacuum on turbine steam rate it is possible to obtain a chart such as that shown in Fig. 10 for a typical 30,000-kw. unit as built about ten years ago. It is obvious from this figure that both an adequate supply and a supply at low temperature are highly de-

sirable, and that expectable variations in water conditions show expectable variations of the order of 10 per cent in turbine performance.

It is not commonly realized that a power plant of 100,000 to 150,000 kw. capacity really uses as much water for condensing purposes under favorable conditions as a city of about 1,000,000 inhabitants uses for sanitary purposes.

The character of the water with respect to cleanliness is also very important. Water containing impurities which tend to build up deposits on the walls of the condenser tubes is particularly undesirable. Such deposits cause fairly rapid increase of back pressure as they accumulate, so that the cost of fuel per kilowatt-hour increases continuously as the deposit accumulates. Also periodical cleaning periods are required. This must involve a direct expenditure for labor in all cases, since no completely satisfactory device has yet been produced for displacing human effort for this purpose. This cost when referred to a single kilowatt-hour is not ordinarily a very serious item, running in the hundredths or even thousandths of a mill. But in most cases the cleaning is a messy and unliked job, and one which necessitates shutting down both turbine and condenser. When the units can be spared easily at night such shutdown does not involve a loss of capacity. When this is not the case the cost of lost capacity may place a very heavy charge on dirty circulating water.

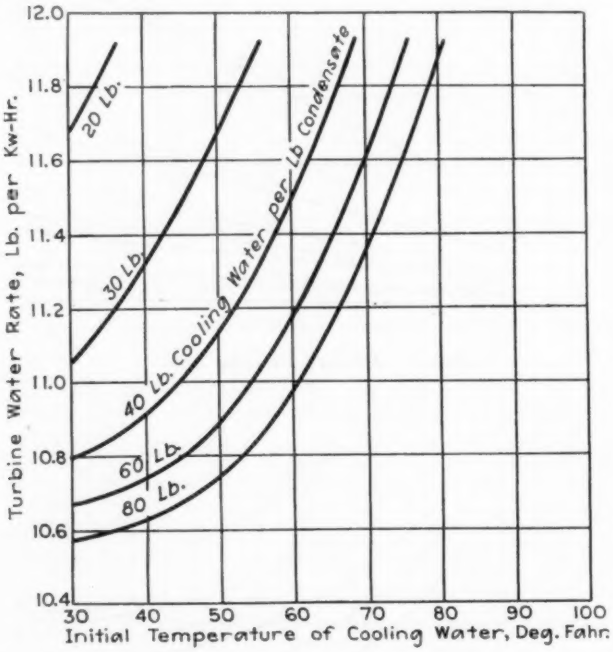

Fig. 10 Effect of Varying Cooling-Water Temperature on the Steam Consumption of a 30,000-Kw. Turbine at Its Most Economical Point. Ratios of Cooling Water to Condensate as Indicated

Summing up this matter of circulating water, it is perfectly possible to operate a power plant with high-temperature circulating water and with comparatively small quantities of it, and also with very dirty circulating water. However, every departure from an adequate supply of low-temperature, clean water brings a corresponding increase of cost of power and a corresponding decrease in the convenience of operation.

The character of feedwater available is no longer the problem that it once was in the larger central stations. This is because of the small percentage of make-up characteristic of a modern surface-condenser plant and the use of evaporated make-up. In cases in which jet condensers must be used and in cases in which steam is lost in large quantities so that large amounts of make-up must be used, the character of feedwater is of great importance.

The actual cost of treatment with 100 per cent make-up and exclusive of fixed charges may vary from much less than 0.1 mill per kw-hr. to many times that amount, depending on the character of the water, the conditions of operation, and many other factors. In general, the actual direct cost is not a serious item, but the complication that it entails and the costs of errors and carelessness are most undesirable.

At this point it is well to note that many plants running on evaporated make-up experience scale deposition in boilers. This is due both to priming of evaporators and to leakage at condenser-tube packings. It requires very skilful and painstaking operation to exclude foreign matter from the working fluid of a steam plant, and very few if any plants are completely successful in doing this.

Probably the largest single item in determining the cost of power, other than the local cost of fuel, is the choice of equipment and the way in which it is assembled. It is possible to purchase and assemble equipment today which will yield a plant capable of producing a kilowatt-hour for less than 12,000 B.t.u. on the one hand and well over 20,000 B.t.u. on the other, and still fall within what one might call defensible design. Obviously the correct solution in any case results from a proper balance between many factors such as fuel cost, investment, permanence, rate of growth, character of personnel, etc.

It is generally considered that the exceedingly rapid rise of boiler pressure that has occurred in the past decade is responsible for the exceedingly rapid improvement in the thermal performance of power plants. This, however, is by no means the whole of the story.

Plants operating at about 200 lb. pressure and 600 deg. fahr. total temperature built as long ago as 1915 actually produced a kilowatt-hour at the outgoing lines for about 20,000 B.t.u. Since that time we have raised boiler-room efficiencies from 76 or 78 per cent to values approaching 90 per cent, representing a decrease in fuel consumption of the general order of 13 per cent. The adoption of the regenerative method of heating feedwater resulted in a further improvement. This cannot be evaluated without considering pressure also, but its effect is of the order of 5 to 10 per cent, depending upon the pressure. We have also increased the total steam temperature 100 to 125 deg. fahr., representing a further gain of possibly 4 per cent. We have also greatly improved the turbine, so that its steam consumption has decreased by possibly 10 per cent.

It is obvious that these separate improvements are of themselves of great significance; in fact, if they were all cumulative they would indicate the possibility of producing power at the old pressure for about 15,000 B.t.u. per kw-hr.

Therefore when we consider the choice of equipment and its arrangement there is much more to think of than merely the pressure at which steam is to be produced or the temperature at which it is to leave the superheater. And it should be noted that the choice and arrangement also determine the operating facility of the station and the number of men that will be required to operate it.

It is interesting to note in this connection that we do not yet have sufficient experience with high-pressure equipment to know just what its relative cost will ultimately be. At the present time the cost of 1400-lb. equipment is decreasing in comparison with 400-lb. equipment, and it is possible that further decreases may result as the manufacturers and designers gain experience. The result of studies made for a plant now building are shown in Fig. 11. It is obvious that the balance between 400-lb. plant and

1200-lb. plant was very close over a long range at the time this study was made.

Maintenance, the next factor on our list, is a subject that acquires increasing importance as a plant ages. The skill with which the need for maintenance of various sorts is anticipated, and the promptness and care with which it is performed, are largely determinative of the life of the plant and the cost of power after the first few years of use. Maintenance in steam power plants of fairly modern design ranges from less than 0.5 mill per kw-hr. delivered to as high as 1.5 mills in exceptional cases. A figure of 0.75 mill is frequently found to be a good average value over the life of a plant, but it should not be understood that any such figure can be used blindly.

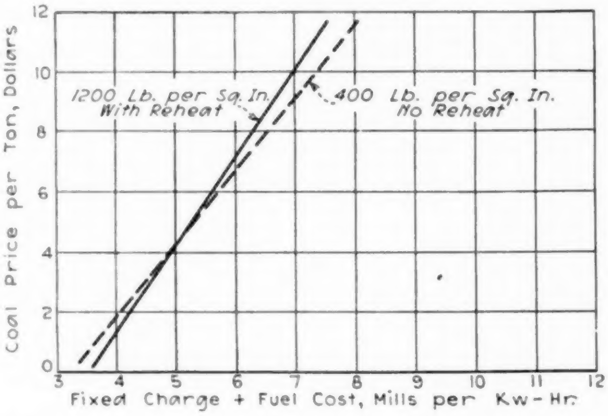

FIG. 11 EFFECT OF COAL PRICE AND STEAM PRESSURE ON COST OF POWER

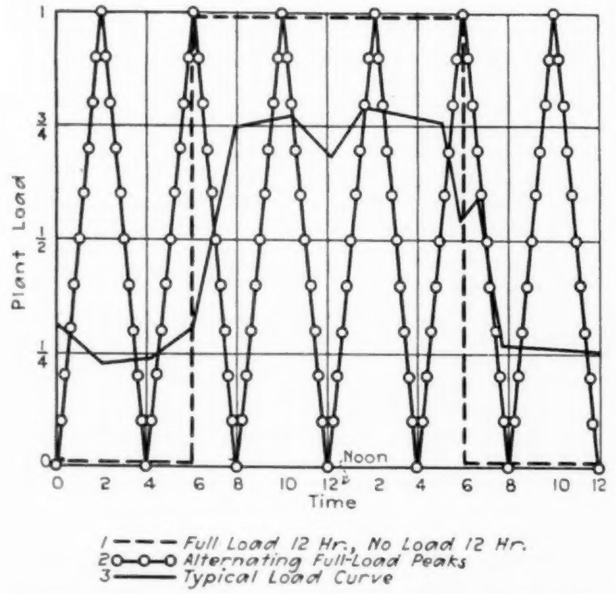

FIG. 12 THREE TYPES OF LOAD CURVE, ALL GIVING 50 PER CENT CAPACITY FACTOR

The degree of steadiness of load which the plant has to carry is another important factor, although it is becoming less so as our combustion equipment becomes more flexible and as we gain experience in the design and application of automatic controls of various sorts. The ideal, from an operating standpoint, would be an absolutely constant load throughout the twenty-four hours of each day throughout the year. Every departure from such an ideal condition brings with it a corresponding increase in the cost of production. The more sudden and extensive the variations in the load, the greater will be the effect upon the cost, with all other things equal.

Much can be done in the design of a plant and in the choice of equipment to limit the increase of cost resulting from very variable or unsteady load. For example, the combustion equipment may be chosen for maximum flexibility and then put under automatic control which can operate sufficiently rapidly to prevent excessive lag in adjustment to a new set of conditions. Feedwater control can be arranged to function in such a way that it is not adversely affected by rapid fluctuations of water level resulting from rapid changes in the rate of steaming. Turbines can be chosen which have very flat water rates over long ranges of load so that the water rate of the plant does not rise rapidly with falling load. This makes boiler operation more difficult but not impossible.

Similarly, much can be done in operation to minimize the effects of fluctuating load. For example, it is possible so to choose the number of units in operation that all overload valves will open with every upward swing of load; it is also possible so to choose the units that the overload valves will not open with normal upward swings. With other things equal, the second method will yield by far the better results on a cost-of-power basis.

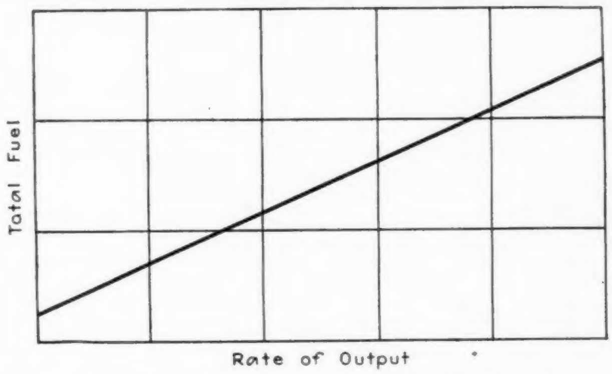

FIG. 13 TOTAL FUEL CONSUMPTION VS. RATE OF PLANT OUTPUT (WILLANS LINE)

Steadiness of load is often confused in its significance with load factor. While it is true that the two ideas overlap, it is also true that there may be and generally are distinct differences. This is illustrated in Fig. 12 in which three radically different types of daily load curve are shown, each representing 50 per cent load factor. It is obvious that the sharply peaked curve indicates a very unsteady load as compared with the other two.

Load factor is at best an incomplete and unsatisfactory measuring stick. The numerical value in a given case will depend upon the time duration used for measuring the peak. In some cases the instantaneous peak is used, in others the maximum 15-min. output, in others the maximum 30-min. output, and so on. It is obvious that the numerical results may be very similar or very dissimilar, depending on the shape of the load curve. However, with any given standard and general type of load curve the load factor by day, week, month, and year does serve as a reasonably satisfactory criterion for measuring plant operation in somewhat the same way that plant capacity factor does in measuring the utilization of the investment.

It was discovered long ago that if the total fuel used at different rates of output be plotted against the rates of output, the line drawn through the resultant points will be substantially straight and will give a marked zero intercept. Such a line is illustrated in Fig. 13; it has been called the Willans Line for the plant. The

zero intercept represents the no-load losses, that is, the amount of fuel required to maintain the plant in readiness to turn out power immediately.

If such a line is really a straight line for any given plant that fact must be regarded as purely accidental, because the line is the result of a number of interacting factors. Thus the turbine water rates will increase after passing the best point, and this should result in increasing the slope of the plant fuel line. Also, the back pressure on the turbines will generally rise as these become crowded, thus tending to raise the plant line at high rates of output. Again, the boiler losses will generally increase markedly at high ratings, and this should have a similar effect. Further, the large increase in auxiliary power required at the boilers at high load will frequently more than balance the effect of the substantially constant auxiliary requirements elsewhere. I am inclined to believe that the fuel line for a normal modern station is always convex downward as shown in exaggerated form in Fig. 14, in which a straight line has been dotted in to indicate the curvature.

Similar lines can be drawn for all items of production cost such as operating and maintenance labor, supplies of various sorts, etc. In general each line will be approximately straight like the

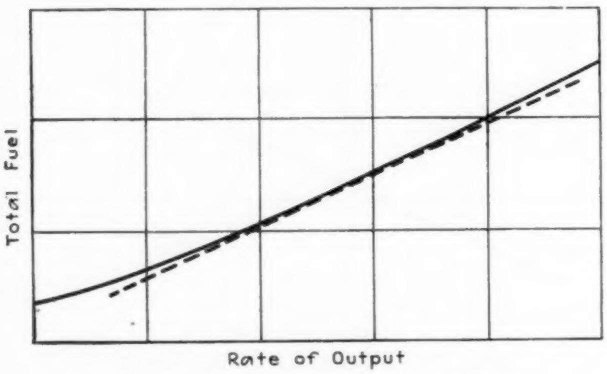

Fig. 14 Total Fuel Curve of a Normal Plant
(Dotted line merely shows curvature.)

so-called Willans Line, but each will ordinarily approximate a slope different from that of the others. When all ordinates corresponding to given rates of output are added there results a combined line which may be called the plant line for total production cost.

In real life few plants operate continuously at constant rates of output. Therefore lines constructed as above are not of maximum usefulness. Similar lines of greater use can be constructed by assuming the plant to operate on typical load curves yielding respectively different annual load factors or annual capacity factors. Such a set of lines for a real plant are shown in Fig. 15. In Fig. 16 are given the resultant unit costs.

It is obvious from the latter curves that the unit production cost decreases as the plant capacity factor increases. And, with normal load curves, the same sort of thing is naturally true with respect to load factor. Since the load factor is not of the operator's choosing but is the result of community life, it is obvious that this item exercises an almost uncontrollable influence on power costs except in so far as the plant designer can provide for it.

And finally, we have the extent to which live reserves are to be carried. This depends upon a great many factors, not the least of which is the ideal set by the executives of the company. Some plants and some systems are so designed and operated that the turbines remaining in operation after the largest unit has been trpiped out can pick up the load dropped by the latter without exceeding the combined capacity remaining in service. If the boilers are similarly conservatively handled, they will be operating easily under normal conditions and can pick up the increased steam demand without effort. This is an ideal arrangement from the operator's standpoint, but rather costly on the side of investment. At the other extreme is the plant which has neither hot boilers nor hot turbines anywhere in the system capable of picking up load dropped by an operating unit. In between are most of the actual operating conditions.

It is quite obvious that the policy adopted with respect to reserves is of great importance in determining power costs. In general the system which makes the most perfect provision for

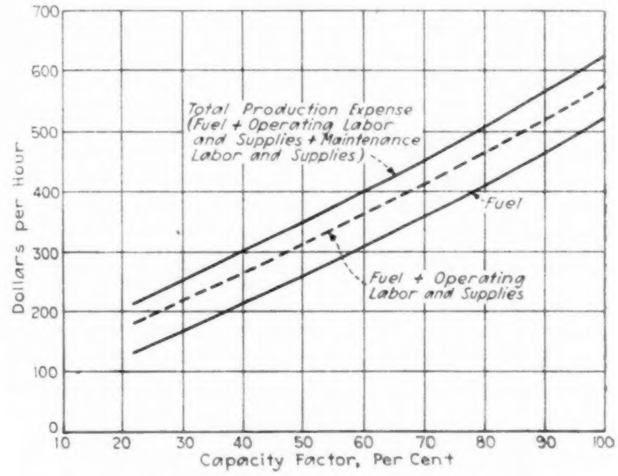

Fig. 15 Effect of Capacity Factor on Production Expense

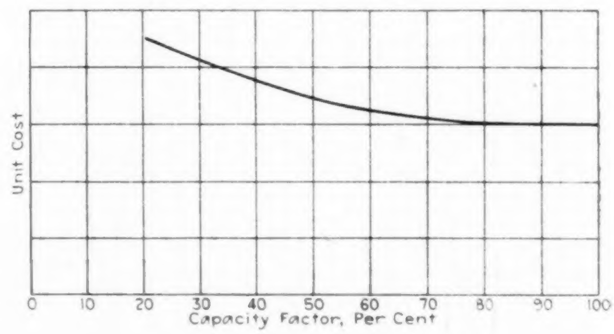

Fig. 16 Unit Production Cost

adequate reserve instantaneously available must handicap itself to the greatest extent with respect to the total cost of power production.

A summary of such a rambling discussion as this has been is well-nigh impossible. It can only be said, as was said at the start, that one not very familiar with the items affecting the cost of producing power is very apt to overlook many of them.

In a paper published in *Industrial and Engineering Chemistry* for October, 1929 (p. 933), W. F. Faragher, J. C. Morrell, and J. L. Essex find that the relationship between calorific value in B.t.u. per pound and A.P.I. gravity of cracked residuums is linear. New formulas for calculating the calorific value per pound of dry oil were determined as follows: 17,010 (90 × °A.P.I.) for the straight-run fuel oils, and 17,645 (54 × °A.P.I.) for the cracked residuums. The calorific value per gallon may be obtained by multiplying each of these expressions by the weight of a gallon of the fuel oil.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

The *i-x* Diagram for Steam-Air Mixtures

THIS is an abstract of the second and concluding part of an article which appeared in the July 20, 1929, issue of *Zeitschrift des Vereines deutscher Ingenieure*, the first part of which was abstracted in the October, 1929, issue of MECHANICAL ENGINEERING, pp. 769–771.

ADMIXTURE OF WATER VAPOR OR WATER WITH AIR

If we add steam or water to air of initial 1 state, the state of the air in the i–x diagram changes according to the straight-line law, because both x and i increase in direct proportion to the added amounts of steam or water. The direction of the straight line is given by the equation $di/dx = i_0$, where i_0 is the heat content of a kilogram of the added steam or water. If it is water, then $i_0 = t_0$. The diagram, in particular the marginal scale, indicates that if we start, for example, with the usual state of room air, fog will ultimately form if we continue to increase the amount of saturated steam added to the air. If for a pressure $p_0 = 1$ atmos. the heat content in the steam added is greater than 640 cal., then if more steam is added the state of the air will gradually emerge from the region of fog, but not otherwise. Taking Fig. 1, $x'_1 - x_1$ and $x'_2 - x_2$ show the minimum amount of steam which can be added to a kilogram of air without forming fog. Hence, if in a unit of time G_0 kg. of steam are introduced into a room, then

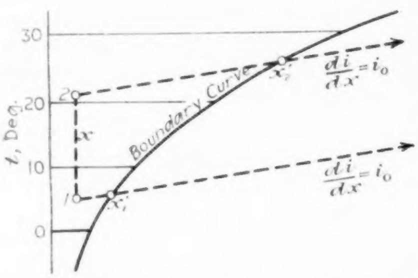

FIG. 1 GENERATION OF FOG UPON ENTRANCE OF STEAM INTO A SPACE, AND PREVENTION OF FOG FORMATION BY VENTILATION AND HEATING

(*Grenzkurve* = boundary curve.)

$$L = \frac{G_0}{(x' - x_1)}$$

is the amount of air that there must be in the room in order to prevent the formation of fog.[1] This amount of air can be decreased by supplying heat to the air, as thereby x_1 is decreased—see Fig. 1.

If, instead of steam, water in liquid form at the temperature i_0 is added to the air until equilibrium is attained, then the following will hold good: $Q = 0$, $di/dx = t_0$; which means that the state of the air varies in the direction of the fog isotherm corresponding to the temperature of the water, or if the latter is not particularly high, then it varies approximately along the line i = constant. We may assume that instead of water, ice is added to the air, in which case the change of state occurs in the direction of the ice-fog isotherm corresponding to the ice temperature.

[1] This formula is exactly as given in the original article.

The above shows what can be done in order to produce a desired state of air, as, for example, in heating or ventilation, and how the i–x diagram may be applied to the solution of such problems.

WHAT HAPPENS WHEN AIR OF A GIVEN INITIAL STATE FLOWS OVER A WATER OR ICE SURFACE OF A GIVEN TEMPERATURE

There is always present above a surface of water or ice a thin boundary layer of air saturated with water vapor and having the temperature of the water or the ice. If a given amount of air at a given state comes in contact with a water or ice surface, a mixing process takes place between the air and the boundary layer referred to above. As a result of this process, the state of the air in the i–x diagram undergoes a change in the direction of the line connecting the state of the air with the state of the boundary layer, the change taking place in accordance with the location of a point of the boundary curve corresponding to the temperature of the water. If the initial humidity content of air x is smaller than the corresponding content of the boundary curve x', the air takes up water vapor from the water (evaporation); should it be greater, then water vapor is precipitated from the air into the water (dew formation).

The criterion $x \gtrless x'$ naturally coincides with that given by Dalton, $p \lesseqgtr p'$. Mixing of the air and boundary layer takes place gradually by small particles of the air mixing first with the boundary layer, then fresh particles of air mixing with this mixture, and so on. All of this mixture phenomena must, however, of necessity lie on the straight lines referred to above (which is true, however, only as long as the temperature of water remains invariable).

If it be assumed that no heat exchange with the ambient medium takes place, the temperature of the water will remain constant only on condition that for a given state of air the temperature of the water is equal to that of the fog isotherm given by that state of air. In such a case the exact amount of heat required for the evaporation of water and raising the temperature of the steam will be given by the cooling of the air. This would be exactly the same as the case discussed elsewhere in the present article, where it was assumed that water of a given temperature is injected without any fresh supply of heat into a stream of air of a given initial state and comes into equilibrium with the air. Should the water originally have a higher temperature than that indicated above, heat will be lacking to effect the process of mixing with the boundary layer, and this heat must then be taken from the supply of water, as a result of which the surface of the water will undergo a cooling until the boundary temperature—and hence a state of constant equilibrium—has been reached. If the original temperature of the water is lower than the boundary temperature, heat is liberated during the process of mixing with the boundary layer. This heat is taken up by the water, the temperature of which rises until again the boundary temperature is reached. The boundary temperature of water appropriate for a given state of air is called in engineering the "cooling limit" (*Kühlgrenze*). The simplest way to find it is by plotting in the i–x diagram a number of fog isotherms in the

unsaturated region. The fog isotherms represent the lines of equal "cooling limit." All that has been said above applies also to the case of contact of air with the surface of ice and to the saturated boundary layer located above it.

In Fig. 2, A represents the state of the boundary layer over a water or ice surface of temperature t_1. Should unsaturated, or as a limit case, completely saturated air come in contact with this surface, the direction of the processes that take place is determined by the position of the state of air with respect to the following four lines, namely, the limit curve, the tangent to the limit curve, the line x' = constant, and the air isotherm through A and the extension of the fog isotherm passing through A.

The Psychrometer

What happens in the August psychrometer, which is already one hundred years old, corresponds exactly to the process described above. Could we but assume that no heat exchange with the ambient medium takes place, then the wet-bulb thermometer would indicate a "cooling limit." The deviations due to the heat exchange with the ambient medium are in the aspiration psychrometer very much reduced by increasing the inner heat conversion as compared with the unavoidable outer heat exchange, and by good insulation.

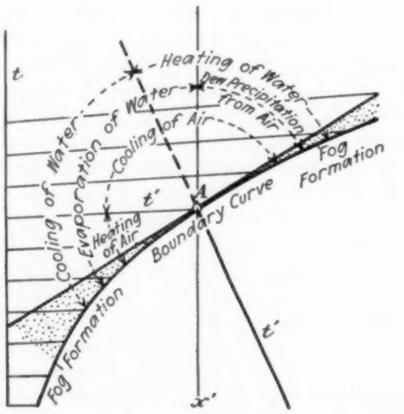

FIG. 2 EXCHANGE RELATIONS BETWEEN A WATER OR ICE SURFACE AND AIR IN CONTACT THEREWITH

Assuming that the wet-bulb thermometer indicates the cooling limit t, the state of air which has to be determined by the i–x diagram can be read off directly, it being only necessary to prolong the fog isotherm t' until it intersects with the air isotherm t (dry-bulb thermometer). Analytically x can be determined from

$$\frac{i' - i}{x' - x} = t'$$

together with the following formula for i and i':

$$x = x' - \frac{c_L + x'c_D}{r' + c_D\,(t - t')}$$

In this formula, which is not limited to mixtures of water vapor and air, x' refers to the temperature of the wet-bulb thermometer and x to the state of air being measured, while r' is the heat of evaporation at temperature t'. In the case of steam-air mixtures with $r' = 595 - 0.54\,t'$,

$$x' - x = \frac{0.24 + 0.46\,x'}{595 + 0.46\,t - t'}\,(t - t^1) = \frac{c'}{Q}\,(t - t')$$

Here c' is the specific heat of the humid air having a water content x', while Q is the heat that is necessary to evaporate 1 kg. of water of temperature t' and bring it to temperature t.

In meteorological work the following simple formula is used to evaluate psychrometer measurements:

$$p' - p = Ap_0\,(t - t')$$

Here p' is the pressure of saturated water vapor corresponding to a temperature t', and p is the partial pressure of steam in water which it is desired to determine, while p_0 is the total or barometric pressure. A is the so-called psychrometer constant, which in the case of an aspiration psychrometer is usually given as 0.00066. The limit value of A in the case when the wet-bulb thermometer indicates exactly the cooling limit, can be easily calculated from the above equation for $x' - x$ by substituting for x' and x the pressures p' and p. If we denote by C_L and C_D the specific heats of air and steam per mol, the following expression is obtained for the limit value of A for any mixture of gas and steam:

$$A = \frac{C_L - \left(2C_L - C_D\right)\frac{p'}{p_0} - \left(C_D - C_L\right)\left(\frac{p'}{p_0}\right)^2}{M_Dr' + \left(C_D - C_L\right)\left(1 - \frac{p'}{p_0}\right)\left(t - t'\right)}$$

From this it follows that in the case of water vapor-air mixtures the following equation for A is obtained on the assumption that the specific heat of air at temperatures between 0 and 20 deg. cent. has the average value of 0.2407 (as given by the Imperial Physico-Technical Bureau) and $C_D = 0.464$:

$$A = \frac{0.388 - 0.314\,\frac{p'}{p_0} - 0.074\left(\frac{p'}{p_0}\right)^2}{r' + 0.074\left(1 - \frac{p'}{p_0}\right)\left(t - t'\right)}$$

Here $r' = 595 - 0.5\,t$ might be inserted. The quadratic member the numerator is extremely small and may be neglected. The second member in the denominator comprises at most two per cent of the heat of evaporation. Likewise the barometric pressure is of very small influence, so that except in unusual cases it may be taken to have an average value of 750 mm. This gives the simplified expression

$$A = \frac{0.388 - 0.00042\,p'}{595 - 0.54\,t'}$$

where p' is to be expressed in millimeters of mercury. The following series then shows the only remaining influence of p'.

For t'	=	0	5	10	15	20	25	30	35	40	45	50°
$A \times 10^6$	=	649	651	652	652	651	650	647	643	636	627	615

Here A passes through a flat maximum which happens to lie exactly in the most used range of temperatures. The average value for A in this region, namely, 0.00065, accords very well with the value derived from experience for the aspiration psychrometer, from which a conclusion might be drawn that the wet-bulb thermometer in this instrument is set at a "cooling limit." The author discusses next the value of A for ice. A list of reference is appended. (Paper by Richard Mollier, of Dresden, initially published in the memorial volume issued on the occasion of the 70th anniversary of A. Stodola; reprinted in and abstracted from *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 29, July 20, 1929, pp. 1009–1013, *pA*. The first part of the article was abstracted in MECHANICAL ENGINEERING, October, 1929, pp. 769–771)

Short Abstracts of the Month

AERONAUTICS

The Prediction of Airfoil Characteristics

THIS paper describes and develops methods by which the aerodynamic characteristics of an airfoil may be calculated with sufficient accuracy for use in airplane design.

The author claims that it is possible to determine the lift and moment coefficients by theoretical computation and the profile drag coefficients by empirical derivation for any angle of attack up to the burble point. The region at or near the burble point, however, is not of great importance.

For the lift coefficient a formula has been developed involving k (correction factor for inefficiency of airfoil), the value of which has been determined to be approximately 0.875 from many tests conducted at a high Reynolds number in the variable-density wind tunnel. The drag coefficient has been determined by dividing the drag of a wing into two parts, the profile drag and the induced drag. It has been generally believed that the profile drag is the same for all values of C_l (absolute lift coefficient). But from tests on many airfoils at a high Reynolds number in the variable-density tunnel it appears that this is not the case, and it is now believed that the variation in profile drag for these airfoils is similar and follows the power law. The rest of the paper is not suitable for abstracting, but from a comparison with observed wind-tunnel test data at full scale it is found that a very close agreement is obtained between the predicted and the actual characteristics of airfoils. (Geo. J. Higgins in *National Advisory Committee for Aeronautics Report* No. 312, 1929, 13 pp., 17 figs., *te*)

ELECTRICAL ENGINEERING (See Power-Plant Engineering: The Mascarini Alternating-Current Electrical Steam Boiler)

ENGINEERING MATERIALS (See also Research: Research on the Liquid Shrinkage of Cast Iron)

Heat-Resisting Steels—Creep Determination

THE authors divide all determinations of properties of steels in regard to heat into two ranges—one below 650 deg. cent. (1202 deg. fahr.) and the other above that temperature. The reason for selecting 650 deg. cent. as the dividing line is that above that temperature the effect of heat treatment substantially disappears.

As regards determination of creep, the authors call attention to the fact that if at all possible it can only be done by means of tedious tests extending over months and perhaps years. There have been many efforts to substitute for such long-time determinations comparatively brief tests with the idea of obtaining in this way data on long-time endurance of materials. Such tests as have been made hitherto, however, would indicate that all these attempts at quickly determining creep values must be viewed with considerable suspicion. Fig. 1 gives data of a long-time test carried out by an American by the name of Duff (apparently communicated to the authors by Mr. Duff personally and as yet unpublished elsewhere). These tests lasted over a period of 7200 hr. and show clearly how little it would be possible to obtain the same picture by any short-time test.

The method developed in Germany by Pomp and Dahmen for the determination of long-time strength by short-time tests (Proceedings of the Kaiser Wilhelm Institute for Research in Iron, 1927, pp. 33, in German) are valuable not for the determination of the absolute values but for comparison between various kinds of steel. The authors refer further to an American paper by J. J. Kanter and L. W. Spring in Proceedings of the American

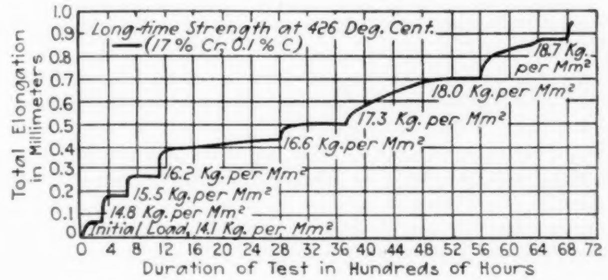

FIG. 1 LONG-TIME STRENGTH-TEST CURVES (DUFF)

Society for Testing Materials, vol. 28, pt. 2, pp. 80–106, and even reproduce as their Fig. 2, curves of Fig. 18 of that paper.

They state also that the Krupp Company has developed at Essen an improved process by which they can obtain information as to the comparative flow of various alloys at given temperatures and loads, but not to a sufficient extent to permit the publication of details. One of the features of this process is that various properties of steel are tested at the same time in the same device. In this way the peculiarities of the various apparatus and even slight changes in temperature are eliminated, and the methods of testing become completely uniform. The remainder of the paper, while of interest, cannot be abstracted here because of lack of space. (E. Houdremont and V. Ehmcke in *Kruppsche Monatshefte*, vol. 10, July, 1929, pp. 79–94, 15 figs. *eA*)

Beryllium

IT WOULD appear that there are today two principal methods of producing beryllium. One was developed simultaneously and independently in Germany and America and is controlled by the Beryllium Institute of the Siemens-Halske Co. in Germany. The whole operation is unique in that electrolysis of sodium and barium beryllium fluorides proceeds at a temperature of 1300 to 1350 deg. cent., which is necessary in order to obtain the metal in fused form.

The American procedure, invented by H. S. Cooper and his associates, involves the electrolysis of far less corrosive a salt, and differs also in that the temperature of electrolysis is along more orthodox lines, about 750 deg. cent. These advantages are counteracted in part by the fact that the metal is obtained in the form of spangles, which must be pressed and fused together. On the other hand, the German metal runs only about 98 per cent in purity, and a higher grade of material can be obtained only by a similar melting.

The standard American metal runs well over 99 per cent in beryllium, with iron representing about 0.20 per cent and silicon 0.10 per cent. Certain changes in technique lead to the hope that all or most of the iron will soon be eliminated, which would carry beryllium into the realm of the highly pure metals.

In America the main effort has been directed to developing the use of beryllium in light alloys, while in Germany for the most part the alloys studied have been those of copper, nickel, cobalt, and iron.

These all show remarkable improvements in properties when heat treated, a copper alloy with 2.39 per cent beryllium showing a Brinell of 100 prior to treatment and then rising to 440 after a

17-hr. soaking at 300 deg. cent. The tensile strength of untreated metal is approximately 70,000 lb. per sq. in.; after treatment the order of magnitude is 194,000. Transverse bending strength goes from 77,000 to 310,000 and the yield point rises from 22,500 to 183,000. The elastic-limit rise is even more astounding; before treatment 7200 is indicated—after, 65,600. The alloys can be worked and rolled without difficulty prior to heat treatment; afterward they are hard and tough, their ductility decreasing proportionately.

Nickel and cobalt show much the same general characteristics—a nickel alloy with 2.5 per cent beryllium will have a Brinell hardness of over 500 after heat treatment. The iron alloys are readily comparable with the standard carbon steels, though this series of alloys has received scant attention as yet as compared with what the subject merits.

Specifically, the beryllium-aluminum alloys offer interesting possibilities as engine pistons, because of the low thermal expansion of beryllium, approaching that of cast iron. This is particularly so in the aeronautical field where every ounce of weight is of importance. The same is also true for their moving parts—connecting rods and the like—but here the far greater strength of the beryllium alloys comes into play, so that smaller cross-sections would give equal strength. Not only in the airplane power plant but no less in the fuselage proper, beryllium will ultimately offer its services as a component of all-metal planes, and in the structural members of other types. Salt-water corrosion normally plays havoc in hydroplanes, and here beryllium alloys should be particularly of value, since they are much more immune to this type of attack than any of the metals now in use for the purpose.

A very serious objection to the extensive use of beryllium is its price. The present price of $200 per lb. is, of course, artificial. It is believed that the metal could be manufactured at less than $5 per lb. if and when the market absorbed 100 tons or more per annum. (Menahem Merlub-Sobel in *Metals and Alloys*, vol. 1, no. 2, August, 1929, pp. 69–70, *d*)

Linatex Rubber

THIS process is carried out directly upon the latex as received from the plantation, and the product is said to contain usually about 95 per cent rubber. The exact method of manufacturing this rubber is not mentioned. It is stated that the new material can only be produced in the form of sheets either in the pure state or reinforced with fabric. A solution has been devised with which lap and butt joints can be made which are said to be able to deliver the same life and strength as the material itself.

Some of the earliest applications of this material (developed by Bernard Wilkinson and called "Linatex") were to the alluvial-tin industry of Malaya. The launders and chutes leading from tin dredges have been lined with Linatex with extraordinary results. Where in the past white iron and manganese steel were employed and gave lives of four or five months, Linatex of about 4 per cent the weight of the metal liners has already been in use for periods up to 18 months without the slightest sign of wear. The "shoes" of gravel pumps, the throats of hydraulic elevators, and the bores of pipes conveying abrasive mixtures of solids and water have been similarly protected with Linatex with outstanding results. There have yet to be found cases where, provided sufficient thickness has been applied to give the requisite resilience, any definite signs of wear have been found.

Tube-mill liners have been fabricated out of the raw material and have already been in service for considerable periods, again without signs of wear. Perhaps the most severe application as regards temperature and active influences has been in the form of pads between rail flanges and soft-wood sleepers on the F.M.S. railways, and between rails and sleepers, sleepers and decking, and main soleplates and concrete abutements on bridges on the same railway system. A pad of unreinforced Linatex has been exposed for a full year to the tropical heat of the open track, and the material still retains its strength and resilience, apparently quite unimpaired. Such results justify the statement that in Linatex there is something quite new, a material which sets a new standard in rubber and a material with literally immense possibilities. Linatex is still an organic compound, and as such, subject to chemical change, to polymerization, and to gradual deterioration, but compared with ordinary rubber it is for all practical purposes chemically inert.

It is also stated in the article that this material can stand very much better than ordinary vulcanized rubber the heat and sunlight in a climate like Malaya. (*The South African Mining and Engineering Journal*, vol. 40, pt. 1, no. 1976, Aug. 10, 1929, pp. 663–664, *d*)

FOUNDRY

Centrifugal Casting of Long Pipe

THIS article describes the Franchi-Gregorini system operated at a foundry in Brescia, Italy. An interesting feature of this process is that each machine covers a wide range of diameters and lengths, and that the changing over from one diameter to another can be accomplished in about half an hour. Pipes can be cast in any length from 7.5 meters (24.60 ft.) down. The casting machine consists essentially of a long bottom frame designed to carry a special truck mechanically driven by an electric motor through reduction gears that permit a quick speed variation. A trough internally lined with refractory forms hangs over the end of this truck. The trough moves horizontally inside the rotating metal mold and pours into it the molten metal in the exact quantity delivered by the pouring ladle. The rotating metal molds rest on a number of cast-iron rolls carried on two longitudinal shafts electrically driven. The revolving speed of the molds varies from 150 to 1300 r.p.m. according to the diameter of the pipes to be cast. The rotating speed of the flask, the horizontal speed for the trough, and the quantity of molten metal are factors bound together by rigid laws. The casting operation proper is accomplished in less than 18 sec., but the rotation of the mold is continued until the iron is solidified. It is stated that the molds are made of special iron cast in a peculiar way. The original article gives analyses and photomicrographs of the castings. (Emilio Franchi in *Foundry*, vol. 57, no. 17, Sept. 1, 1929, pp. 757–760, 13 figs., *d*)

FUELS AND FIRING (See also Power-Plant Engineering: A Symposium on Boiler-Room Chemistry)

The Starkey Low-Temperature Distillation Process

THE basic idea of the Starkey retort for low-temperature distillation is to expose the coal or other material to be distilled to a succession of controlled and gradually increasing temperatures between 200 deg. cent. and, say, 500 deg. cent., without dilution of the products of distillation or direct contact with the heating medium. In a retort of, say, six hearths, the material is exposed, in the first two hearths, to a moderate temperature, and the steam, gases, and condensable hydrocarbons from these two stages are taken to a water-cooled condenser via a dust catcher. The products from the next two stages go, again via a dust catcher to a hot-water condenser and then to the cold-water condenser, while those from the two final

stages pass to a hot-air condenser before completing their journey via the hot-water condenser to the cold-water one. The result is that there is no opportunity for the tars produced to form emulsions and sticky messes which have proved so disastrous in other layouts of low-temperature distillation apparatus. The material under distillation is mechanically rabbled from hearth to hearth, first inward and then outward, and the heating gases are kept entirely separate from the distillation products. Arrangements are made to play either heated incondensable gases or superheated steam on the material in each hearth via the rabble arms, and in all hearths but the first the material is subjected to heat not only from below and above by radiation and conduction, but also to direct heat from the steam of heated gases or steam issuing from the rabbles which are moving and agitating the mass in its passage across the hearth.

The incondensable gases, which are moderate in quantity per ton of coal or other material put through, are used for heating purposes in the retorts. As far as the gases are concerned, the average material distilled gives no more than are required for heating purposes, so that a good balance is secured in this respect.

The process has not yet been demonstrated on a commercial-plant scale. (*The South African Mining and Engineering Journal*, vol. 40, pt. 1, no. 1976, Aug. 10, 1929, pp. 661–662, *d*)

MACHINE PARTS (See Special Processes: Developments in Chromium Plating)

MEASURING INSTRUMENTS

A Turbine Gas Meter

At the beginning of the war, the writer carried out a large number of tests on model propellers with the plane of rotation inclined at various angles to the direction of motion, in order to ascertain whether flight on the helicopter principle was practicable. The model propellers tested were rotated by a small air turbine, the driving torque of which was determined by calibration in terms of the air pressure at the jet driving the turbine. It is from this turbine that the shunt gas meter has grown.

It was found during the above experiments that over a very large range of speeds the revolutions of the turbine were exactly proportional to the volume of air passed through the impact nozzles, and that it was only at low speeds, where the energy delivered to the turbine per second was small, that the constancy of the ratio of air volume to revolutions fell out.

It appeared that the jet-driven turbine gave the simplest means of obtaining a counter record of the flow of air, gas, or steam. In a turbine meter only one freely rotating shaft (apart from the counter train) had to be designed so that its frictional resistance to rotation would remain negligible after months of running. Since the 1915 experiments, successful and accurate meters on the turbine principle for measuring each of the fluids referred to have been developed.

In this meter an orifice is placed in the gas main and this orifice diverts a certain proportion of the gas through a shunt circuit placed above the orifice. The turbine is placed in this orifice. Gas impinges on the turbine through two diametrically opposite nozzles so that there is no side thrust on the bearings. A damping fan is used to keep the speed of the turbine low so as to reduce the wear on the bearings. A feature of the meter is that its accuracy can be checked at any time by comparing the readings of a flow-indicating manometer connected across the orifice in the meter with the counter readings. (John L. Hodgson in *Journal of Scientific Instruments*, vol. 6, no. 8, Aug., 1929, pp. 258–261, 3 figs., *d*)

METALLURGY (See Research: Research on the Liquid Shrinkage of Cast Iron)

MOTOR-CAR ENGINEERING

The Reo Gear Change

The Reo Motor Car Company has adopted in the new master "Flying Cloud" a new three-speed transmission with a silent second speed and herringbone gears for the constant-mesh and second-speed gear train. It is claimed that a shift without clashing from high to second speed can be made at speeds up to 40 m.p.h., and from second to high at any speed of the engine. As the herringbone gears cannot be shifted, a dog clutch is used for engaging the second gear. It is claimed that in addition to greater tooth contact for a given width of gear and greater quietness, the construction reduces vibration. The right- and left-hand teeth on the main-shaft gear have different tooth pitches.

To insure quiet running, side play on the intermediate gear on the main shaft and the driven gear on the countershaft can be adjusted by means of a screw collar. Adjustment of several thousandths of an inch is provided.

A new alloy, developed by the Aluminum Company of America, is being used in the pistons. The material is called "Low-Ex," and the coefficient of expansion is said to be less than that of alloys used previously, while the conductivity is from 15 to 20 per cent greater. As a result the piston clearances are reduced to 0.003 in. (*Automotive Industries*, vol. 61, no. 9, Aug. 31, 1929, pp. 305–306, 2 figs., *d*)

The Ruxton Front-Wheel-Drive Gear

The arrangement of engine auxiliaries in the Ruxton car differs from that customary on rear-drive cars in that both the generator and the pump are located on the left or valve side of the engine and are driven in tandem. The starter and battery are located on the right-hand side, the battery being under the engine hood, which makes it more accessible than usual.

As regards the transmission, one of the problems that confronts the designer of front-drive passenger cars arises from the fact that with the present vogue of the eight-in-line engine, the distance between the front axle and the dash comes out abnormally long if the usual arrangement of parts is adhered to. This makes it necessary either to use a long wheelbase or to cramp the body. To overcome this difficulty the transmission in the new Ruxton is cut in halves, as it were, one half being located in back and the other in front of the driving axle. This cutting in halves, however, applies only to the gears and not to the transmission as an assembly. From the standpoint of assemblies, the arrangement adopted may be better described by saying that the transmission and final drive have been combined in a single unit, the worm of the final drive being part of the splined shaft and having some of the change-speed gears on each side of it.

In addition to this the two parallel shafts are located side by side instead of one above the other. This was done as there is no room for the secondary below the primary shaft. With the two transmission shafts located side by side the housing is comparatively shallow. Very rigid supports for the bearings of the worm shaft are obtained by tying together the cross-walls of the case in which they are mounted, the walls running parallel with the worm. The front-axle assembly is of course unusual. The carrying member of the front axle is of I-section but is curved forward to the center of the car to avoid the differential-drive housing, while the axle ends instead of being at the level of the wheel hub are about 4 in. lower. The housing for the worm-drive gear is split horizontally through the axis of the gear, the upper half of the worm gear and differential being con-

tained in what is really the transmission housing and the lower half in a separate housing of cylindrical form. The steering knuckle is of rather unusual form. In accordance with the usual practice of using high-grade alloy steel for this part, it is made of chrome-molybdenum steel. Where the ordinary knuckle comprises a spindle on which the front wheel revolves, this knuckle has a bearing shell supporting ball bearings in which the driving spindle is mounted. This spindle extends beyond the shell at its outer end, and has the hub of the driving wheel keyed to it on a taper. A yoke formed on the lower side of the bearing shell spans the boss at the end of the axle and serves to pivot the knuckle to the axle center. In addition the knuckle serves one other function, and that is as a support for the front-wheel-brake back-up plate, to which end it is provided with a flange at the inner end of the bearing shell to which this plate is riveted. It will be noticed that the knuckle pivot is inclined so that its axis meets the ground near the center of the tire contact.

There is one obvious advantage in having the knuckle-pivot bearings below the wheel center, and that is that in case of a lateral shock to the wheel, as in side skidding, collision with a curb, etc., the resulting momentum is considerably reduced, hence for a given force of impact the additional load on the bearings is less. The steering tie rod lies directly behind the axle center and is therefore fully protected by it against injury.

Much of the sheet-metal work on the car is quite out of the ordinary. Thus the radiator shell is formed with large depressions in the sides which are finished in the same color as the body, while the raised portion is chromium-plated. The radiator filler cap is sunk entirely below the level of the radiator shell and is secured in place by a sort of bayonet joint which requires only a slight angular motion to lock or loosen it. (P. M. Heldt in *Automotive Industries*, vol. 61, no. 9, Aug. 31, 1929, pp. 298–301, 4 figs., *d*)

POWER-PLANT ENGINEERING

A Symposium on Boiler-Room Chemistry

A NUMBER of papers on boiler-room chemistry were presented before the joint meeting of the Divisions of Industrial and Engineering Chemistry, Gas and Fuel Chemistry, and Water, Sewage, and Sanitation Chemistry at the meeting of the American Chemical Society, Columbus, Ohio, April 29 to May 3, 1929. Several of these papers are abstracted below.

Rate of Burning of Individual Particles of Solid Fuel

An apparatus and method are described for determining the rate of burning of individual particles of solid fuels under controllable conditions of furnace temperature, particle size, and oxygen concentration.

Typical data for three sizes of coal and two sizes of semi-coke and active charcoal are presented and discussed as follows: (*a*) Under the experimental conditions, fuels containing high-percentages of volatile matter show a pronounced increase in burning time with increasing furnace temperature; (*b*) fuels containing practically no volatile matter show a much smaller temperature coefficient over the temperature range covered in the experiments; and (*c*) active charcoal requires a considerably longer period to burn than coal or semi-coke of the same size (weight per particle). (H. J. Griffin, J. R. Adams, and David F. Smith, Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa., pp. 808–815, 16 figs.)

A Theory of Liquid-Film Formation

Liquid films are always formed by the approach to each other, usually with an extension of area, of two already formed liquid surfaces. In the case of solutions the mechanical force acting to bring the surfaces together meets with resistance when the layer of liquid between the surfaces becomes very thin, with the result that a film is produced. In the case of pure liquids no such resistance is encountered, and consequently the two surfaces merge and vanish. The reason for the counter force in the case of solutions is the difference in concentration between the surface layer of the liquid and the mass of the liquid. Solute either concentrates in the surface or recedes from the surface. In either case this movement of matter takes place against osmotic pressure, and it will therefore require work to restore the equality of concentration; in other words, thin surface layers will resist a force to mix them. This theory harmonizes the puzzling facts that both positively and negatively adsorbed dissolved matter cause foam in liquids, and explains why pure liquids do not foam.

The statement is also made that film formation and film stability are separate questions which have often been confused in the literature. (F. W. Foulk, Department of Chemistry, Ohio State University, Columbus, Ohio, pp. 815–817.)

Laboratory Tests With a Foaming Boiler Water

Laboratory tests indicate great improvement as regards foaming when organic coloring matter is removed from a boiler water, either by coagulation and filtration or by oxidation. On the strength of these experiments provision has been made for the treatment of water with aluminum sulphate and sulphuric acid for the removal of the suspended and organic matter. (A. S. Behrman, International Filter Co., Chicago, Ill., pp. 817–818.)

Chemical Proportioning of Internal Feedwater Treatment

Operating results are given to show that harmful scale formation may be prevented at low cost through the use of organic matter in conjunction with quantities of inorganic chemicals far below the quantities necessary to react chemically with the scale-forming constituents of the feedwater. A means for conveniently applying the treatment is described. (E. M. Partridge, Paige, and Jones Chemical Co., Hammond, Ind., pp. 819–821, 1 fig.)

Zeolite-Deconcentrator Combination for Boiler-Water Purification

The use of zeolite water softener operating in combination with deconcentrating equipment eliminates the undesirable features of zeolite-softened water for boiler-feed purposes, reduces operating cost, minimizes blowdown, and provides a clean boiler water which will produce clean steam.

The high caustic concentration caused by zeolite-softened water is replaced by insoluble matter permitting the normal sulphate content of the raw water to provide in a majority of cases an adequate sulphate-alkalinity ratio for the prevention of embrittlement.

The combination system operates by softening but a portion of the water by the zeolite system and bypassing a large quantity of raw hard water. The reaction between the soft and hard water creates sludge, which is uniformly and continuously removed from the boiler by the deconcentrating system. The results obtained with a combination system covering a period of 200 days under boiler-room conditions are shown with curves and tables in the original article. (Elwood W. Scarritt, Elgin Softener Corporation, Elgin, Ill., pp. 821–823, 3 figs., 2 tables.)

Some Examples and Precepts of Water Conditioning

Operating data are given to show the results obtained in boiler plants where the author's system of water conditioning has been used. Experiments with anti-foaming material indicate that other means should be taken to avoid wet steam in modern stationary boiler plants. (R. E. Hall, Hall Laboratories, Inc., 304 Ross St., Pittsburgh, Pa., pp. 824–829, 1 fig., 7 tables.)

IMPROVED EQUIPMENT FOR THE TREATMENT OF FEEDWATER FOR MODERN STEAM BOILERS

This paper directs attention to the importance of proper feedwater treatment for the modern high-pressure boiler which frequently operates at 400 to 1200 lb. per sq. in. pressure and occasionally considerably higher. Attention is directed to the value of the research investigations of Parr and Straub, Hall, and Foulk, whose writings have appeared in various technical publications.

Illustrations and descriptions are given to show practical methods of treating water with phosphate to supplement the hot-process lime and soda treatment and also deaeration. A recently developed sulphuric acid feeding equipment is described for treating boiler feedwaters to give a proper relationship of sodium sulphate to sodium carbonate from the embrittlement standpoint. This equipment is adapted for use with zeolite softening or with natural waters high in sodium carbonate. The proportioning of sulphuric acid is accomplished by balancing the differential pressure caused by water flow through an orifice with an air pressure which imposes a corresponding pressure of the sulphuric acid solution upon a small chemical orifice, thus insuring a flow of sulphuric acid solution proportional to the flow of water. All parts of the equipment coming in contact with acid solution are made of lead or rubber.

A continuous blow-off equipment is described for removing the mineral solids as they concentrate in the boiler in such a manner as to recover the heat of the blow-off water. A steam purifier is illustrated to remove moisture from the steam before the latter enters the superheater.

A conclusion is drawn that the modern high-pressure, high-rating boilers can be operated with satisfaction if proper equipment is installed for treatment of the boiler feedwater and if it is operated in accord with the recent disclosures of various water-purification engineers. (Joseph D. Yoder, Water Purification Dept., Cochrane Corporation, Philadelphia, Pa., pp. 829–834, 7 figs.)

MECHANISM OF FORMATION OF CALCIUM SULPHATE BOILER SCALE

THE early stages of calcium sulphate scale formation on a heated surface have been observed in an experimental apparatus utilizing the principle of the metallographic microscope. It has been observed that bubbles of dissolved gas or steam formed on a heating surface in contact with a saturated solution of calcium sulphate cause the deposition of crystals at the solid-liquid-vapor interfaces formed by the surface, the solution, and the bubbles.

On the basis of the experimental work a new theory of scale formation on a boiler heating surface is presented. This theory states that the initial deposition of scale crystals takes place directly on the surface as the result of the formation of steam bubbles. If the substance so deposited has a negative solubility slope, the crystals will continue to grow by contact with the supersaturated liquid film at the heating surface. If the substance has a positive solubility slope, the crystals may either completely redissolve in the undersaturated liquid film at the heating surface, or this tendency toward resolution may be overbalanced by the rate of deposition of new crystals by the process of bubble evolution.

The bubble-evolution theory of scale formation discredits the "colloidal" theory of scale formation. It agrees with Hall's theory concerning the growth of scale, but goes further than this theory in explaining the deposition in scale at heating surfaces of substances with positive solubility slopes.

The rate of scale formation is believed to be chiefly a function of the rate of heat transfer across the boiler surfaces, and of the slope of the solubility curve of the scaling substance. (Everett P. Partridge and Alfred H. White, Dept. of Chemical Engineering University of Michigan, Ann Arbor, Mich., pp. 834–838, 5 figs.)

THERMAL EFFECTS OF BOILER SCALE

New determinations of the coefficient of heat conductivity of calcium sulphate boiler scales made in an experimental boiler at pressures up to 150 lb. per sq. in. gage are reported. The coefficient of heat conductivity measured by various investigators on nineteen boiler scales varied between 1.3 and 3.06 kg-cal. per sq. m. per hr. per meter thickness of scale per deg. cent., with an average value of 2.15.

According to Eberle and Holzhauer, the conductivity of boiler scales decreases with increase in porosity, and very porous silicate scales may have heat-conductivity coefficients as low as 0.1, or one-twentieth of the average value for dense, non-porous sulphate scales.

The effect of boiler scale upon heat utilization is very slight, probably amounting to not more than 3 per cent for a scale 2 mm. in thickness in a boiler operated at high ratings.

While scale is relatively unimportant from the standpoint of loss in heat utilization, it is very important from the standpoint of temperature elevation in the metal of scaled heating surfaces. At the high rates of heat input by radiation occurring in water walls and in front-row tubes, thin scales formerly regarded as unimportant may cause failure due to overheating.

A simple graphical solution of the heat-flow equation is given for the rapid estimation of metal temperature increases caused by different rates of heat transfer, for scales of different thicknesses and heat conductivities. (Everett P. Partridge and Alfred H. White, Dept. of Chemical Engineering, Univ. of Michigan, Ann Arbor, Mich., pp. 839–843, 5 figs., 3 tables. Abstracted through *Industrial and Engineering Chemistry*, vol. 21, no. 9, Sept., 1929, pp. 808–844, *dpt*)

The Mascarini Alternating-Current Electrical Steam Boiler

THE principle of operation of this boiler is by the immersion in water of three electrodes connected to a three-phase supply. Rate of steaming is controlled by varying the height of water, thus altering the area of elements immersed.

An electrical relay system is used for regulating the boiler output. A transformer controlling the relay is inserted in the circuit supplying the electrodes. When the current rises to a value exceeding that desired, due to the water level being to high, the relay operates and makes contact to a coil fitted on the boiler. This coil controls a valve which opens on contact being made and bypasses the water from the boiler back to the feed tanks until the required value of current is reached.

No heat or water is lost by this method, as the water is again fed to the boiler. In order to vary the setting at which the relay operates, a coil is inserted in circuit with it in the transformer secondary. This coil has an adjustable iron core, and by varying this the circuit impedance is altered, thereby varying the load at which the relay comes into action. It is claimed that by this system the load can be regulated to within 5 per cent. The diagram of the layout is shown in Fig. 2. For safety purposes a lever safety valve is provided, but in order to prevent frequent blowing off, with the resultant waste of steam, an additional device is provided which has a lower setting than the safety valve. When the pressure is approaching blowing-off point this device opens a valve and allows the boiler water to be blown back into the feed tank; it may thus be termed a safety valve on the water side. As the boiler is immediately emptied and the circuit broken, all danger is averted without entailing any loss of heat or water.

According to the original article the striking feature of a demonstration recently made in London was the rapidity with which steam was raised from cold water, the whole operation from start to finish occupying less than 10 min. The system is automatic in its action, regulating the supply of steam to the

set value without any attention. The operation is simple, as it is only necessary to close the main switch and start up the pump in order to put the boiler in operation. The shutting down is equally simple. As a supply of steam can be obtained in a few minutes it is not necessary to keep a head of steam overnight or on week ends. The boiler can be built in small units, and is now

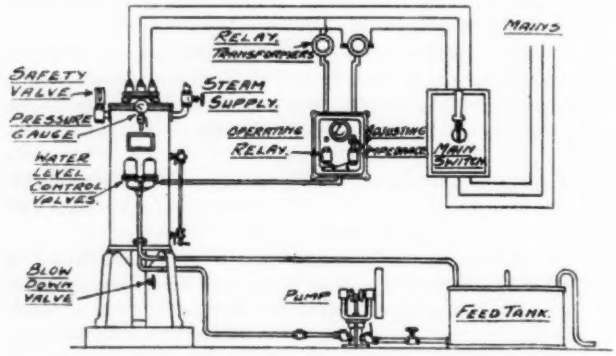

Fig. 2 Diagrammatic Layout of Mascarini Boiler Equipment

available in a range of sizes up to 300 kw. It is claimed that the working efficiency is 98 per cent. It is said that there are over 500 of these boilers in service in Italy. They are now being introduced into England. (*Electrical Times*, vol. 76, no. 1973, Aug. 15, 1929, pp. 234–235, *d*)

Monolithic Baffles in Boilers

IN THE author's plant, baffles in 250-hp. Edge Moor boilers failed after several years in service. Estimates for replacing tile baffles in three of these boilers amounted to $1200, whereupon it was decided to build monolithic baffles, using a refractory gun. This was done as follows: 2-in. × 4-in. wood stringers were laid across the tubes to support a latticework of 1-in. × $1^1/_8$-in. slats. The slats were placed diagonally down each lane between the tubes, with crossed diagonal slats down each lane from the opposite direction. These slats were fastened to the stringers across the top and beneath the bank of tubes. In this manner the operators built the forms for front and rear baffles of three of the boilers—six baffles in all.

The quantity of material required for the six baffles was as follows:

Dry refractory material	4200 lb.
High-temperature cement	3200 lb.
Portland cement	1 bag

Commencing at the bridge wall, the operators shot the mixture from the gun against the latticework, using at first a short nozzle. As the work progressed the operators extended this nozzle with sections of $^3/_4$-in. pipe.

After applying the material the operators tamped it with a special tool made of $^1/_2$-in. pipe about 6 ft. long and flattened for about 18 in. at one end. With this tool they not only could tamp and smooth the surfaces of the baffles, but by turning it on edge they could work the material snugly in around the tubes.

The operators did not build the baffle to full thickness in one application but alternated between front and rear baffle, giving each successive layer an opportunity to dry and set slightly before applying the next layer. A slow fire was started soon after the baffles were completed to dry them out, and about eight hours later the boiler was raised to the steaming temperature. The wooden lattice was left in place and allowed to burn away.

The operators were surprised at the speed of application, and found they had made a good job at very low cost. Their own figure on the cost of front and rear baffles for three boilers is as follows:

7400 lb. refractory mixture (high-temperature cement and crushed firebrick)	$226.70
1 bag of Portland cement at $0.70	0.70
200 ft. of lumber at $12 per C	24.00
55 hr. labor at $1	55.00
55 hr. labor at $0.62	34.10

This makes a total cost of $340.50 for material and labor for the six baffles.

The monolithic baffles have proved to be gastight and enable the plant to operate on an average of 135 per cent of rating over 24 hr. with peaks as high as 180 per cent in these hand-fired boilers. The average stack temperature was brought to 495 deg. fahr., with 560 at the peak, which indicates a good, tight baffling job. A considerable saving of fuel was also effected. (W. E. Smith in *Southern Power Journal*, vol. 47, no. 9, Sept., 1929, pp. 85–86, 1 fig., *dp*)

Commercial Uses of Submerged Combustion

THE development of burners of this type covers almost a century, Collier having obtained a patent on it in 1887. Of late two types—one by Brunler, and the other by Hammond—have reached the stage of really commercial application. Both

Fig. 3 The Hammond Burner Applied to a Central Hot-Water Heating Plant

have been previously described in Mechanical Engineering (the Brunler in vol. 47, no. 5, May, 1925, p. 358, and the Hammond in vol. 51, no. 9, September, 1929, p. 695).

Practical application of this burner to a hot-water heating system unit is shown in Fig. 3. The burner 8 is installed as shown with the exit end in the circular chamber or air-lift foot piece 10. Water from the main tank 27 flows down to the circulator tube and is carried up to the head tank 17 by the air-lift

action of the steam and products of combustion. From this tank the heated water flows through the outlet 16 to the hot-water radiators and, returning, enters at 19, cascading down to the chamber 27 over the deflectors 21. Gases of combustion and steam descend around the riser pipe as indicated by arrows, pass up under the deflectors, countercurrent to the entering water, where the steam is condensed and the gases are cooled to the lowest possible temperature before leaving by way of the vent 13.

The efficiency depends upon the heat loss in the saturated exit gases. If the maximum obtainable efficiency reached when the returns are at atmospheric pressure is considered as 100 per cent, the losses will vary with the temperature from 1.75 to, say, 10 per cent. Such efficiencies are far beyond those of other heating systems.

Pressures in steam generators with submerged burners are considerably higher than those of usual steam boilers operating at equal temperatures. For instance, burning coal gas of a certain composition and generating 10.43 lb. of steam at 482 deg. fahr. per pound of gas would give 10.43 lb. of steam and 9 lb. of non-condensable gas with a total pressure equal to the sum of the partial pressures of the steam and gas at 482 deg. fahr., that is, 450 plus 282 or 732 lb. per sq. in. abs.

Practically any fuel such as produces coal or water gas, carbon monoxide, hydrogen, oils, and pulverized coals, can be burned in this manner. Combustion is controlled by a single handwheel which regulates both the air and fuel so to maintain the definite proportions needed for complete combustion through the entire range of the burner. (*Power Plant Engineering*, vol. 33, no. 17, Sept. 1, 1929, pp. 944–946, 8 figs., *dh*)

RAILWAY ENGINEERING

Effect of O'Fallon Decision on Valuation and Rate Making

THE author discusses the question of what will be the effect of the O'Fallon decision upon the railroads in the matter of determining the basis of recapture of railroads and making of group rates. As to recapture, the court has not held that the railroads must always be valued on the basis of their present-day construction cost. It merely stated that the Interstate Commerce Commission was wrong in its method of determination which neglected the present-day construction costs. The conclusion to which the author comes is that the principles established by the court should not ordinarily justify a value less than the present-day reproduction value. As regards valuation and rate making, he points out that the O'Fallon decision stabilizes the situation, because hereafter the adequacy of railroad rates must be judged by the standard of present value and the rate reductions will have to be scrutinized from the viewpoint of the substantive law thus declared. He believes that as a matter of right the railroads under this decision are entitled to better earnings than they have ever had. (Leslie Craven, Counsel, Western Group, Presidents' Conference Committee on Federal Valuation of Railroads, in *Railway Age*, vol. 87, no. 5, Aug. 3, 1929, pp. 341–343, *g*)

REFRIGERATION

The Kolbe Floating-Pan Freezing System

A UNIT of this type has been placed in operation by the Booth Fisheries Co. of Boston. In this system the fish to be frozen are placed in round seamless stamped pans, 22 in. in diameter and 3 in. deep, and floated through a long raceway on very cold brine. The raceway is 2 ft. wide, 10 in. deep, and is as long as is necessary for the capacity desired. This raceway is doubled back and forth under the storage-room floor, with the ends projecting outside for loading and unloading.

The freezing system is placed under the storage-room floor and occupies only 12 in. of space above the cork insulation. The raceways start outside the room at one end where it is convenient for loading the pans. The first run is to the back of the storage, then lengthwise of the room on the floor, back and forth, with the end outside in the warm room.

These raceways are built by placing 2 × 10-in. planks on edge, forming a trough 2 ft. wide. This trough is lined with galvanized iron, and in most cases 20-gage Toncan or Armco iron is used in sheets 8 ft. long and 3 ft. wide. The separate sheets are bent lengthwise in a trough form 2 ft. wide and 6 in. deep. These iron troughs are placed end to end between the 2 × 10-in. planks, the iron being nailed at the edges and the joints soldered tightly.

Calcium brine is used in this system. In the Booth Fisheries plant the brine remains in the raceways all the time. A centrifugal pump, whose suction is connected to the end of the raceways in a well, provides all the circulation. It pumps about 175 gal. per min. from the end of the raceway through the shell-and-tube brine cooler and to the beginning of the raceway again. A bypass is arranged to get the circulation of brine through the cooling coils in the cold storage. The pump also does all the work of conveying the pans of fish through the freezer while freezing.

About 5 lb. of fish fillets, or six pieces nearly an inch thick, are placed in each pan. The loaded pans are put on the flowing brine at the starting point and float away, disappearing into the storage room under the floor. They are not then seen again until emerging at the end of the freezer. The brine of course travels faster than the pans, so that a good velocity results on the pan surface, which gives a good heat transfer between the brine and the fish as well as a force pushing the pans through the freezer. Where the raceway turns or doubles back a curved bumper plate is fastened to guide the pans. With the slant in the floor, more velocity results at the turns, which assists the pans around. When regulated properly, no trouble results by pans sticking.

The pans of frozen fish coming up on the conveyor are given a sharp tap on the table by the knock-out man. The fish crack loose without thawing and are dumped into the chute leading to the storage room. This is a very simple and easy operation. The empty pans are moved on a conveyor chain to the starting point again, and as they move across the room they are refilled with fish. In regular operation the pans never stop, but keep a steady movement through the freezer, to the knock-out man, to the panners, and into the freezer again.

The Gorton Pew Fisheries Co., in Gloucester, Mass., is now (September) completing the largest unit of this kind so far installed. It will have a raceway 950 ft. long, which will give them a freezing capacity of about 2000 lb. of single fillets per hour. This unit is placed on the second floor of a new building recently constructed. The brine, in this case, runs from the end of the raceway to a small tank on the first floor with a float-valve attachment controlling the brine level in the tank. The centrifugal pump, pumping 300 gal. of brine per min., sends the brine through a shell-and-tube cooler to the raceways on the second floor again. A York 10 × 10-in. compressor driven by a uniflow steam engine supplies the refrigeration. (*Ice and Refrigeration*, vol. 77, no. 3, September, 1929, pp. 153–154, 4 figs., *d*)

SPECIAL PROCESSES

Developments in Chromium Plating

THIS paper discusses certain applications of chromium plating, and incidentally mentions some of the physical properties of the plate. Among other things, it would appear that com-

paratively little is known about the true adhesion of the plated coatings. Both the condition of deposition and condition of service have a marked effect upon the adhesion. The adhesion of chromium is also more or less governed by the difference in the coefficients of expansion between the base metal and the deposit, the value of the coefficient for chromium being much less than that for copper, brass, iron, steel, nickel, and aluminum. This fact must account for the tendency which the deposit has to crack and flake away from articles used at a high temperature.

The original article gives some interesting information on the behavior of chromium-plated hacksaw blades. The following table presents results of comparative tests with ordinary hacksaw blades, both types being 14 in. long, with 10 teeth per inch.

	Ordinary saw blade, time of cut in minutes		Chromium-plated saw blade, time of cut in minutes		
Cut	No. 13	No. 14	No. 19	No. 20	Material
1	20	18	27[1]	25 (broke 3/4 way through section)	Steel forgings
2	20	20	13 (broke 1/2 way through section)		
3	18	20			
4	22	20			
5	20	20			
6	17	23			
7	23[1]	22			
8	25	27			
9	23 (broke 3/4 way through section)	28			
10		32			
11		10 (broke 1/4 way through section)			
	No. 15	No. 16	No. 21	No. 22	
1	70	45	50 (broke 3/4 way through section)	55 (broke after cutting 1 inch through section)	Steel tire
2	65 (ceased cutting 1/2 way through section)	95 (ceased cutting 3/4 way through section)			

NOTE: All the saw blades were tested under conditions as nearly alike as practicable.
[1] Teeth breaking off.

The following are results obtained in tests with chromium-plated drills:

Material drilled, 2-in. steel, with 37/64-in. drill at 390 r.p.m.

A	Special tool steel	65 holes were drilled
B	Special tool steel	80 holes were drilled
C	(A) Chromium plated	150 holes were drilled

Material drilled, 1 1/2-in. slate, with 13/16-in. drill at 300 r.p.m.

D	Special slate twist drill	10 holes
E	Same, chromium plated	28 holes
Material and drill as before, but speed 120 r.p.m.		
F	Unplated	19 holes
G	Plated	55 holes
Material as before, but 1/4-in. drill at 300 r.p.m.		
H	Unplated	40 holes
I	Plated	200 holes

Chromium-plated drills also showed up to advantage on molded stone, bakelite, and asbestos boards.

It is a matter of common observation that a twist drill fails when the points of the lips become worn away so that the drill does not clear itself and begins to bind. A probable explanation of the advantage given by the chromium deposit is that it reinforces the periphery of the drill and prevents the lips from being worn away.

On saw blades the tendency of the chromium to pile up on the teeth destroys the efficiency of the blade. Further, the preliminary treatment of the steel destroys the temper, and in many cases the blade snapped before the end of its useful life.

The results noticed and reported on files were similar to those on hacksaw blades. Any appreciable thickness of plating tended to destroy the keenness of the file. On the other hand, a thin coating of chromium was found to be an advantage in the filing of soft non-ferrous metals. Such metals as brass, copper, and aluminum tend to clog the file and reduce its efficiency. The greasy surface of chromium certainly minimizes this effect, and in many cases it would be an advantage to utilize a thin chromium coat, even if the resulting life of the article was not increased.

The original paper discusses the application to machine parts, particularly valves and valve seatings in pumps used in the ceramic industry, where chromium plating proved to be very successful. The same applies to printing rollers and printing plates. In forming tools the results were not so satisfactory, although in drawing dies a certain amount of success has been achieved. By far the best results have been obtained, however, on dies and molds used for the forming of such plastic materials as rubber, ebonite dust, bakelite, etc. (Leslie Wright, Research Department, Metropolitan Vickers Electric Co., Ltd., in *Machinery* (London), vol. 34, no. 881, Aug. 29, 1929, pp. 680–682, *dp*)

RESEARCH

Research on the Liquid Shrinkage of Cast Iron

THE Committee on Cast Iron, as one of its activities, has outlined a study of developing methods for testing those properties for which at present no test methods are available. In the report of the committee as presented at the 1929 convention (preprint 29-17) there is given a list of properties of cast iron of interest to the metallurgist, founder, and engineer. In this report it is stated that while many of the properties are measurable with present methods, there are some important ones for which no adequate tests are available. "We have no good test for machinability, resistance to wear, and abrasion," the report states; further, "the main concern of the foundryman from the standpoint of shrinkage, 'piping,' etc., is in that contraction between the initiation of freezing and the completion of freezing, and it is this phase of freezing that is especially under attack by your committee at the Bureau of Standards." (*Bulletin, American Foundrymen's Association*, vol. 8, no. 3, August, 1929, p. 11, *d*)

Research at the Land-Grant Colleges and Universities

THIS publication contains a list of land-grant colleges and universities together with the names of the engineering research organization connected with each of them, research funds available, engineering research projects under way, discontinued, or completed, and publications of the engineering experiment station. ("A Summary of Engineering Research at the Land-Grant College and Universities," published by the Engineering Experiment Station Committee, Association of Land-Grant Colleges and Universities, edited by R. A. Seaton, Secretary, 1929, 98 pp., *gs*)

TESTING AND MEASUREMENTS (See Engineering Materials: Heat-Resisting Steels—Creep Determination

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Test Code for Stationary Steam-Generating Units

Proposed Revision of a Code in the Series of Twenty-Two, Formulated by the A.S.M.E. Committee on Power Test Codes

The Main Committee on Power Test Codes takes pleasure in presenting to the Members of the Society the proposed revision of the September, 1924, edition of the Test Code for Stationary Steam-Generating Units for criticism and comment. The Individual Committee which developed this revised draft of the code consists of Messrs. E. R. Fish, Chairman, A. D. Pratt, A. D. Bailey, A. Iddles, E. B. Powell, and E. B. Ricketts. It is believed that in its present form this Code meets the needs of all groups which from time to time have a part in the making of acceptance tests of this type of apparatus.

In 1918 the Committee on Power Test Codes was organized by the Council of the A.S.M.E. to revise and enlarge the Power Test Codes of the Society published in 1915. This Committee consists of a Main Committee of 25 members under the Chairmanship of Fred R. Low, and 20 individual committees composed of specialists who are drafting test codes for the various prime movers and the other auxiliary and related apparatus which constitute power-plant equipment.

Complete copies of the revised draft, of which the following is a very brief abstract, may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this code from those who are specially interested in the manufacture, use, and testing of stationary steam-generating units. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

THE Individual Committee with the full knowledge and consent of the Main Committee has changed the designation of the Code from "Test Code for Stationary Steam Boilers" to "Test Code for Stationary Steam-Generating Units." This action was taken for the reason that the development of power-plant practice has resulted in the widespread adoption of other major heat-absorbing apparatus as well as the greatly changed nature and importance of fuel-burning apparatus. Consequently a new paragraph has been added to the Introduction of the Code as follows:

1 *Definition.* A steam-generating unit is a combination of apparatus for producing, furnishing, or recovering heat, together with apparatus for transferring the heat so made available to the fluid being heated and vaporized.

NOTE: For the purpose of this code such a unit will include boiler, water walls, water floor, water screen, superheater, reheater, economizer, air heater, furnace, and fuel-burning equipment. Economizer and air heater are not included when the heat absorbed is not returned to the unit.

The scope of the Code was consequently changed to read as follows:

2 *Scope.* The Test Code for Stationary Steam-Generating Units applies to all of the component parts as defined in Par. 1 but not to the apparatus required for their operation, such as engines and motors for driving stokers, feed pumps, draft fans, etc.

The paragraph dealing with guarantee tests has been modified as follows:

11 *Guarantee Tests.* It is therefore quite logical in the case of guarantee tests that a substantial compliance with the guarantee be accepted as full compliance therewith. On the other hand, unless a limit of tolerance is agreed upon beforehand by the parties to the test, no tolerances should be allowed. The amount of this tolerance might well bear some relation to the care exercised in arranging the details and in the conducting of the test.

Under "Instruments and Apparatus" the paragraph covering gages has been revised as follows:

14-*e* *Gages.* Pressure gages should be away from any disturbing influences, such as extreme heat, and in a position to be easily read.

Draft should be measured at not less than two points: (1) after the flue gas has passed beyond contact with any part of the boiler and before passing the damper, or before entering the outlet duct if there is no damper, and (2) in the furnace immediately before the flue gas comes in contact with the heating surface of the boiler proper, which in the case of vertical or steep-tube types of water-tube boilers should be midway of the tube length. It is often desirable to know the draft at other points of the setting, in which cases the several locations should be chosen to suit the information wanted. Care should be exercised to see that the ends of the connecting pipes are not obstructed and that the open ends are not subject to other than static pressure. All joints of draft-gage connections must be tight.

The following substitution for the paragraph on "Power for Auxiliaries" has been made:

37 *Power for Auxiliaries.* It is recommended that a record be kept of the energy used by auxiliaries immediately connected with the steam-generating unit being tested, and that a specific note be made thereof. This applies particularly to steam or power used in driving stokers or other fuel-feeding apparatus, fans, feed pumps, and soot blowers, and may also include such energy used in fuel preparation.

It is always difficult and usually impracticable to determine accurately the steam equivalent of the power used by auxiliaries. For this reason no deduction shall be made in computing Items 80 and 81 (Evaporation), Items 90–93, inclusive (Efficiency), or any of the data of the heat balance unless the object of the test so requires, in which case the report should specifically so state. It is frequently desirable, however, to compare the performance of installations of different types, and for this purpose a close approximation of the overall efficiency of the steam-generating unit, corrected for auxiliaries, is of value. The deduction of such approximate auxiliary energy steam equivalent from the total steam will give an approximate "net efficiency of the steam-generating unit." The code makes no attempt to define this item exactly or to specify how it should be determined because of essential dependence upon the characteristics of the individual installation. Whenever this "net" value is given, a full statement should accompany the report, setting forth the apparatus for which deductions have been made and the method used in determining such deductions.

Under "Data and Results of Stationary Steam-Generating Units," in Table S1c, "Computations for Test of Stationary Steam-Generating Unit (Solid Fuels)" the following additions have been made:

Item 18—The steam-generating unit heating surface shall consist of that portion of the surface of the heat-transfer apparatus exposed on one side to the gas or refractory being cooled and on the other to the fluid being heated, measured on the side receiving heat. This item equals the sum of Items 13, 14, 15, 16, and 17.

Items 13 and 14—Boiler heating surface shall consist of that portion of the surface of the heat-transfer apparatus in contact with the fluid being heated on one side and the gas or refractory being cooled on the other, in which the fluid being heated forms part of the circulating system; this surface shall be measured on the side receiving heat. This includes the boiler, water walls, water screens, and water floor.

Heating surface located in the furnace or furnace boundaries shall be measured as follows:

A Tubes wholly exposed or partly embedded in refractory—that portion of the surface of the tubes which is exposed to the gas or refractory being cooled.

B Tubes provided with extended surface—that portion of the surface of the tubes and the extensions which are exposed to the gas being cooled.

C Tubes protected by blocks rigidly attached to the fire faces—that portion of the surface of the blocks which is exposed to the gas being cooled.

Item 15—Superheater surface shall consist of that portion of the surface of the heat-transfer apparatus exposed on one side to the gas being cooled and on the other to steam being heated after leaving the boiler circulating system, the surface being measured on the flue-gas side.

Item 16—Economizer surface shall consist of that portion of the surface of the heat-transfer apparatus exposed on one side to the gas being cooled and on the other to fluid being heated before entering the boiler circulating system, the surface being measured on the flue-gas side.

Item 17—Reheater surface shall consist of that portion of the surface of the heat-transfer apparatus exposed on one side to the gas being cooled and on the other to steam being heated after expansion, the surface being measured on the flue-gas side.

Item 19—Air-heater surface shall consist of that portion of the surface of the heat-transfer apparatus exposed on one side to the gas being cooled and on the other to air being heated for combustion, the surface being measured on the flue-gas side except that in air heaters of the regenerative type, where the surfaces are alternately in contact with gas and air, the air-heater surface shall be determined for the purpose of this code by multiplying the total surface of the apparatus by that proportion continuously in contact with the gases being cooled.

The above changes apply also to the similar computations for liquid and gaseous fuels.

These suggested changes will require the addition of several items in the report forms and the omission and changes of others, all of which are of a wholly editorial nature, and need not be reproduced here in detail.

Correspondence

Analysis of Strains and Stresses in a Wristpin

To the Editor:

The writer wishes to call attention to what seems to him to be fundamental errors in elementary strength of materials at the beginning of paper No. APM-50-2, Trans. A.S.M.E., by Guy B. Collier, entitled "Analysis of Strains and Stresses in a Wristpin." These errors, to some minds, would seem to nullify completely the value of the complicated mathematical analysis that follows.

A study of Mr. Collier's given conditions in the last half of column 2, page 1, and first paragraph, page 2, shows clearly that he has a beam with fixed ends (the elastic curve parallel to the X-axis at the end supports) carrying a uniformly distributed load of w lb. per inch over its middle portion, length l'. Further, the beam is also one having two different cross-sections, for he assumes that the hollow pin, bushing, and sleeve act as a unit.

The author then proceeds to derive a formula for M'_x (bottom of col. 1, p. 2) which plainly holds only between $x' = l_c$ and $x' = l_c + l'$. Yet he immediately obtains M_1 at the support by letting $x' = 0$ in this formula for M'_x—but this formula is not valid where $x' = 0$.

The writer would like to raise at least three objections to this part of the work and its analysis. If, as the author assumes, the fixed end is equivalent to a cantilever beam carrying a uniformly distributed load of m lb. per inch, then the moment at R_1 where the slope is horizontal, is $-ml''^2/2$ as for any cantilever beam, and not the value given by the author in Equation [A_1-2]. Of course, the author's error arises from using the equation for M'_x when $x' = 0$.

Secondly, how does one know that the pin load inside of the piston boss is a uniformly distributed load of m lb. per inch? If such is the loading, then the pin must be bent into a curve. But the instant that one curves the pin inside of a rigid boss, uneven pressures are set up. Therefore it seems that to assume uniform loading is wrong. Of course, it is appreciated that the method of fixation has no effect on the range $2l_c + l'$, and so this second objection is not a major one.

But thirdly, and chiefly, the author's expression for M_1 (namely, $M_1 = -wl_c^2/2 - ml''^2/2$, which the writer claims should be simply $M_1 = -ml''^2/2$) does not involve any of the stiffness properties of the beam within the region l_c and l', yet common sense dictates that the moment at the fixed-end support must depend upon the relative dimensions of the pin and the bushing. It makes a difference whether the bushing and sleeve is $^1/_2$ in. thick or $^3/_4$ in. thick as to what the value of the moment M_1 may be.

Mr. Collier, with these wrong assumptions, gets for the moment at the support

$$M_1 = -\frac{w}{12}\left(2\,l_c + l'\right)^2$$

which gives $M_1 = 1300$ in-lb. for the numerical conditions assumed on page 9 of the paper.

Let I_c denote the moment of inertia of the cross-section within the portion l_c and I the moment of inertia of the middle part. The customary methods of double integration, moment areas, or least work all give

$$M_1 = \frac{\dfrac{wl'}{2}\left[\dfrac{l'^2}{6} + l'l_c + \dfrac{I}{I_c}\,l_c^2\right]}{l' + 2\dfrac{I}{I_c}\,l_c}$$

which reduces upon substitution to $M_1 = 950$ in-lb., considerably different from the above 1300 in-lb.

It is to be noted that the author's formula always gives the same result regardless of the cross-sectional dimensions. The writer's value for M_1 will vary, as it should, depending upon the ratio of I to I_c.

Gleason H. MacCullough.[1]

Worcester, Mass.

Diesel Power Costs

To the Editor:

On page 710 of the September, 1929, issue of Mechanical Engineering is a brief account of the second national meeting of the Oil and Gas Power Division of the A.S.M.E. which was held at State College, Pa., June 24 to 27.

In this account the report of the Committee on Costs presented by Mr. Franz Eder is mentioned, and reference is made to so-called "median values." This is incorrect, as it was pointed out at the meeting by myself after a careful analysis of Mr. Eder's report that these values are weighted averages. I believe this distinction should be pointed out as there is a large difference between the median values and the weighted-average values on account of the influence exerted by two or three exceptionally large plants operated at high load factors.

H. C. Thuerk.[2]

New York, N. Y.

[1] Assistant Professor of Mechanical Engineering, Worcester Polytechnic Institute. Assoc-Mem. A.S.M.E.

[2] Chairman, General Power Committee, National Electric Light Association.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK, *Aeronautic Division*	*J. L. WALSH,* *National Defense Division*
A. L. KIMBALL, JR., *Applied Mechanics Division*	*L. H. MORRISON,* *Oil and Gas Power Division*
H. W. BROOKS, *Fuels Division*	*W. R. ECKERT,* *Petroleum Division*
R. L. DAUGHERTY, *Hydraulic Division*	*F. M. GIBSON and W. M. KEENAN,* *Power Division*
WM. W. MACON, *Iron and Steel Division*	*WINFIELD S. HUSON,* *Printing Industries Division*
JAMES A. HALL, *Machine-Shop Practice Division*	*MARION B. RICHARDSON,* *Railroad Division*
CHARLES W. BEESE, *Management Division*	*JAMES W. COX, JR.* *Textile Division*
G. E. HAGEMANN, *Materials Handling Division*	*WM. BRAID WHITE,* *Wood Industries Division*

Railroad

Troubles With High Boiler Pressures

R-1 What troubles have so far been experienced with high boiler pressures on locomotives?

As compared with steam pressures now being used in boilers of central-station, industrial, and marine power plants, those generally adopted for new passenger and freight-train locomotives in the United States and Canada are relatively low, the present maximum standard pressure being 250 lb., whereas during the past ten years large central power-station and marine boilers have had the pressures substantially increased, with the result that 350 lb. is now practically standard, and with numerous regular service installations running at 550 lb. and higher.

The following table illustrates, in a general way, the range of boiler pressures of single and multiple-expansion steam locomotives during the past 50 years.

Year	Range of Pressures	Pressure of Majority
1880	130 to 160	130
1885	130 to 175	130
1890	130 to 180	160
1895	160 to 190	180
1900	160 to 200	190
1905	160 to 215	200
1910	150 to 215	200
1915	170 to 210	180
1920	160 to 220	200
1925	180 to 225	200

The D. &. H. locomotive "Horatio Allen" has now been in road freight service for over 5 years, and the "John B. Jervis" for over $2^1/_2$ years. As a result of their rigid boiler design and construction with provision for uniform and equal expansion and contraction, no major boiler troubles have developed to date. Some of the boiler-shell seams have required recalking, a few of the vertical water tubes adjacent to the fuel bed have been renewed, and several of the throat-sheet water-leg rigid staybolts have been replaced. A few checks have also developed in the throat sheet at the staybolt openings, but otherwise no repairs or renewals of any consequence have been necessary. As the result of this performance D. &. H. Consolidation type locomotive No. 1402, which will carry 500 lb. boiler pressure, is now under construction.

In the case of the conventional Stephenson-type locomotive boilers, equipped with the rigidly stayed crown and side sheets, and carrying pressures up to 250 lb., there have been frequent premature renewals of firebox plates and staybolts due to the relatively sluggish movements of the boiler water in the water legs and around the firebox sheets, and with the accumulation of incrustating and corrosive foreign matter on the water side of these sheets and on the rigid and flexible staybolts, much difficulty has been experienced on account of the sheets and stays becoming mud-burned, leaky, checked, cracked, broken, or otherwise in a defective condition, which has necessitated early renewals. This condition has applied not only to the 225 to 250-lb. pressure locomotive boilers, but as well to those of the lower pressures, i.e., 175 to 200 lb. The latter have been the more general practice, although the application of thermic siphons in combination with fireboxes and combustion chambers has greatly improved the sluggish boiler-water circulation and evaporation surface conditions, and reinforced the crown-sheet staying.

In the designing of high-pressure locomotive boilers, from experience to date, the fundamentals to be considered may be stated as:

1 An absolutely rigid design of boiler in which the rear, or furnace, end will be substantially secured to the forward, or shell, section.

2 Provision for free and uniform expansion and contraction of all of the shell and interior sheets, stays, and water and fire tubes.

3 The use of relatively high-elastic-limit, tough, ductile, and non-corrosive materials.

4 Boiler-shell seams to be of 93 per cent or greater efficiency. Welded seams with supplementary reinforcement to insure positive and adequate factor of safety.

5 Improved conventional firebox crown and side-sheet design and construction with respect to the factors of expansion, contraction, staying, and water circulation.

6 Minimum thickness of metal between the fire, products of combustion, and the water.

7 Edges of the flanged and unflanged sheets exposed to the fire to be thinned and fabricated with countersunk-head rivets.

8 Beads to the fire flues and tubes at the firebox tube-sheet end eliminated or reduced to prevent the adherence of molten ash and slag to the metal and the formation of honeycomb.

9 Maximum heating surface provided adjacent to the process of combustion to secure full benefit of radiant heat for evaporation.

10 Adequate gas area through the boiler fire flues and tubes to eliminate any soaking-heat effect in the furnace.

11 Rapid circulation of the water through or around all evaporation surface tubes and plates.

12 Adequate water capacity and saturated-steam space at the top of the boiler, and collection of the saturated steam from over a large surface area of the steam-generating water to avoid priming, and the use of the superheater as a secondary evaporator.

13 Maintenance of the fire side of the water and fire tubes in an unobstructed and cleanly condition.

14 Elimination of scale formation from the interior of water tubes and the exterior of boiler flues and tubes.

15 Rearrangement of the superheater equipment to prevent loss of heat due to the superheated steam traversing the coldest part of the boiler, and to enable reduction of existing wasteful smokebox temperatures without loss of superheat.
16 Boiler insulation of 98 per cent or higher efficiency.
17 A reliable low-water alarm provided.

(John E. Muhlfeld, Consulting Engineer, New York, N. Y.)

Miscellaneous

CO_2 for Manufacture of Refrigerant

M-9 What are the most common sources of the carbon dioxide used in the manufacture of solidified CO_2 for refrigeration purposes?

Generally speaking, Nature is an inexhaustible source of supply of CO_2 gas. The atmosphere, which contains from 0.003 to 0.004 per cent by volume, is by far the greatest storage magazine. From it the CO_2 is absorbed by the leaves as well as the roots of plants during the process of assimilation which is engendered by light, that is, the rays of the sun. During this process oxygen is set free and expelled into the atmosphere.

Volcanic formations, abysses of the earth, fountains, and especially the sea emit large volumes of CO_2 constantly, so that its relative percentage in the air remains practically constant.

While the atmospheric percentage of CO_2 seems comparatively small, it has been estimated that its total weight is not less than 6 million tons.

The carbonates of the alkali earths and of the metals contain this gas in abundance. Ordinary limestone often contains 40 per cent of CO_2, which is liberated during the burning or calcination of the stone.

Every process of fermentation reduces the saccharose matter of the mash into alcohol and carbon dioxide, practically in equal weights.

Enormous volumes of CO_2 gas appear as the product of combustion of carbon in any form, whether in the form of coal, coke, wood, oil, or natural gas. In each case its separation from the other products of combustion is a commercial possibility and is practiced in many instances.

It is true, of course, that such reduction, separation, and purification offer problems that can be solved only by the initiated and specialists. However, it is available in each case and can be promptly changed into the desired form, whether gaseous, liquid, or, in the final analysis, solid.

Preferred Sources of Supply. The combustion of coal, or more strictly speaking, of carbon, is a most familiar process and has often been mentioned as one of the most prolific sources of CO_2 gas supply. While this is true in a general sense it is not so simple to recover the CO_2 from the combustion gases of a power plant where ordinary steam coal is used as fuel. The gas must be absolutely odorless, colorless, and tasteless, and since coal has many impurities, its purification is a problem fraught with difficulties. However, it is not impossible to purify it entirely, especially since modern furnaces offer the means of reducing these impurities into forms in which they can be suitably eliminated.

Coke, which is very high in carbon and low in impurities, is the best material from which to obtain CO_2 by ordinary combustion. The flue gases are rich in CO_2, up to 20 per cent, and the purification method is reduced to scrubbing it with water.

Limestone in its various forms, up to magnesite or marble, is rich in CO_2. Grecian or California magnesite will give up its CO_2 content by roasting it in cast-iron retorts at a temperature of about 600 deg. fahr. The gas needs only to be cooled in an ordinary enclosed scrubber, and is then immediately available for liquefaction and solidification.

Lime kilns of the ordinary pot-kiln variety are scattered throughout the land. Kilns of higher grade using producer gas or perhaps natural gas as the fuel yields a pure CO_2 gas. However, in this case it is necessary to separate the gas from other products by absorption and subsequent liberation in a heat process.

In rare occurrences CO_2 is produced in industrial plants at high concentration and great purity. In such cases the CO_2 may be separated from the rest of its gaseous mixture by the simple means of stratification.

Alcoholic fermentation produces CO_2 in tremendously large volume. The gas thus obtained is exceptionally pure and needs only to be divested of certain odors which it obtains from the original mash.

In bygone days breweries furnished much of this gas for their own requirements as well as for the market, and many were equipped with complete gas-recovery, compression, and liquefying equipment.

Industrial alcohol is obtained from the residue molasses of the West Indies sugar factories. The process furnishes CO_2 in equal quantities, which is immediately available after passing through a simple scrubbing and deodorization method. Distilleries supplying around 200 tons of CO_2 per day are not at all exceptional.

Investment Cost of Equipment. A magnesite roasting plant is comparatively simple. It requires a relatively small investment for purifying equipment, but its capacity is usually limited and the labor cost is considerable, although this can be compensated for by marketing the exceptionally valuable calcined material. Lime-kiln gas usually contains upward of 35 per cent, but the impure combustion gases of the fuel contaminate it to such an extent that scrubbing, absorption by a soda or potash lye, and subsequent liberation therefrom by means of heat become necessary.

Unfortunately heat and power are not obtainable as a product of burning the lime, so that this immediately becomes a separate item of installation whereby investment as well as labor cost is largely increased.

Cement works usually employ large rotary kilns, and the heat generated for burning the stone is so high that steam can be produced, using it in boilers of adequate design and construction. The only drawback in this case is the impurity of the fuel, which, however, is not insurmountable.

The coke-combustion process has the decided advantage of furnishing CO_2 gas, heat, and power simultaneously. However, the investment cost is always and necessarily high whenever extensive purification, absorption, and liberation equipment is required.

Alcoholic fermentation produces the gas as a free and pure by-product. All it needs is some scrubbing as well as deodorization preparatory to liquefaction. The mechanical devices needed for such preparation are simple and not very expensive. The labor cost is likewise low since the process is automatic and requires but little attention. It is then merely necessary to liquefy the gas by compound compression in multi stages to effect liquefaction, the liquid being subsequently cooled in equal stages, during which heat, as well as pressure, is carefully husbanded so that the liquid may be delivered to the solidifier at a temperature of —30 deg. fahr. or less. Solidification is then performed in a device by further reduction of the liquid temperature to the triple point which is at —70 deg. and 60 lb. gage pressure, and it becomes then a matter of choice as to the form of solidification, whether crystal or solid ice. Freezing of the liquid has the advantage of further reducing the labor as well as the power cost, and on that basis alone is highly to be preferred. (J. C. Goosmann, Engineering Division, Ice and Refrigeration Dept., Frick Co., Waynesboro, Pa.)

Engineering and Industrial Standardization

Diesel-Engine Standardization, and Specialization of Manufacture[1]

"THE idea of standardization in Diesel machinery is developing, and although there has apparently been greatest opportunity for it in Sweden and Denmark, owing to the willingness of Scandinavian owners to adopt completely standardized plant, there are indications of progress in this country (England). For instance, there are eight ships being built, all to have Kincaid-B. and W. machinery with cylinder dimensions 630 mm. bore and 1500 mm. stroke. In all, there are 16 such engines, representing 100 cylinders similar in every respect. Incidentally, according to our records, this firm appears to have 31 Diesel engines under construction for installation in 17 ships."

The *Evening News*, London, tells of efforts made in Germany to obtain cheaper Diesel engines by means of standardization. "A German company whose head is one of the foremost Diesel engineers in the country," says the article, "has had an idea which may lead to a considerable reduction in costs." The article continues:

The makers of Diesel engines must do their own fine work, but according to his theory it is not at all necessary for them to trouble themselves about the host of small parts which are inseparable from every Diesel, and which cost a lot of money when they are made in small quantities.

Such things as silencers, oil reservoirs, purifiers, starting reservoirs, valves, and fuel pumps are worked on the same principle in scores of different types of Diesel engines, and the German engineer's idea is to form a central factory at Stuttgart and turn out these things in large numbers at a very much lower price than the big engineers can contrive at their own works.

Two years' experience in making standardized parts for one particular type of Diesel engine has convinced him that he is on the right road, and he is now prepared to make numerous parts for Diesels of all sorts.

In some of the types which are now at sea this will mean a slight alteration in their design, but nothing that is material either to cost or efficiency.

This German is prepared to do this not only for German engineers, who are taking to the Diesel engines with enthusiasm, but for those in any other country where the import duty is not prohibitive, and he is convinced he can save money even in the face of high tariffs.

Standardization as an American Phenomenon[2]

AN IMPORTANT book on American commercial, industrial, and social life, written from the viewpoint of an intelligent and sensitive European, is "America Comes of Age," by M. André Siegfried, translated from the French by H. H. and Doris Hemming. In his chapter on the Spirit and Methods of American Industry, M. Siegfried makes the following comments on standardization as an American phenomenon which we believe will be of interest to our readers.

The most important point in the philosophy of American production [he says] is the home market of nearly 120,000,000 people. The United States may be the most protectionist country in the world, but it is equally true that inside its implacable tariff wall is an area of 3,000,000 square miles in which there is absolute free trade and which thus constitutes by far the largest entirely free market in the world. Mass production is the logical result. American industry has been built up on broad lines from the very beginning, for it enjoys not merely the entry, but the privileged use, of this enormous market which hitherto has shown an unlimited capacity of absorption. As goods go from the Atlantic to the Pacific without a barrier, a factory can be located at whatever point is mathematically the most favorable, be it Boston, Los Angeles, or St. Louis. Within this closed area the sound laws of free trade, which are distorted everywhere else, hold good. America solves her economic problems by economic methods, and nothing interferes with her commonsense ideas of production. Having no international rivalries such as poison Europe, she can take a large view of things. This is her chief advantage, and in fact is the only way in which modern industry can realize its maximum achievement.

This, however, is only one aspect of the question. Organization of industry is one thing; standardization of the product is another. In older civilizations, where tastes vary according to local customs and refinements of culture, industry is obliged to furnish a great range of models and cannot specialize on a limited number of articles. On the other hand, the 100,000,000 individuals in the United States are astonishingly alike. They all speak the same language, with fewer different accents than are to be found in England; they all live in exactly the same way, and are little influenced by the differences in their climate. The immigrants at first keep a little of their own originality; but owing to the sharp rupture with their traditions, their children fall into line without resistance. With such a stereotyped clientele, industry is not obliged to prepare an infinite number of complicated products. A limited number of models suffices, repeated indefinitely and varying only according to certain fixed principles.

As if the natural similarity of the American people were not enough, "big business" has set to work to accentuate it still further by scientific advertising. . . . . . .

There is nothing unsound in reducing the cost of production by standardization, nor in transferring to the worker in the form of increased wages part of the saving effected and later taking it back by selling him goods. This is a complete cycle and is healthy as long as the country lives independently on its own natural resources. The idea is as clear as crystal, and no doubt that is why it is accepted with such enthusiasm. If one is operating on a basis of a few articles and an unlimited number of consumers, the slightest progress pays automatically, as every one knows. In the Ford works, for example, the most minute economies give tangible results: "We put in more machinery per square foot of floor space than any other factory in the world, because every foot of space not used carries an overhead expense," says Henry Ford. ("My Life and Work," p. 90.)

The conclusion is that wherever the machine, the series, or the organization can triumph, American genius will triumph with it. But it is not adaptable and will not give the maximum output when, instead of disciplined cooperation, constant individual initiative is needed, and an intelligent appreciation of the finished product, as well as artistic ability and unremitting care. . . . . They are not sure of themselves when they try to make to order expensive articles that cannot be standardized. By turning the worker into a cog in a vast machine, they have robbed him of the intense mental activity of the artisan or even the peasant who can think in terms of the finished product, be it a clock, a fruit, or a flower. Thus, wherever standardization is not essential, America does not lead, and is in fact exceedingly vulnerable. . . . .

[1] An editorial in *Motor Ship*, London, for June, 1929. Abstract reprinted from September 5, 1929, issue of the *A.S.A. Bulletin*.

[2] Abstract reprinted from the September 5, 1929, issue of the *A.S.A. Bulletin*.

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of September 15–October 15, 1929:

Building Exits Code. (American Tentative Standard.)
Sponsored by the National Fire Protection Association.
Published by the N.F.P.A.

Safety Code for Textiles. (American Tentative Standard.)
Sponsored by the National Safety Council.

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The Aberdeen Proving Grounds Maneuvers

IMPRESSIVE was the display of defense armament made under the auspices of the Army Ordnance Association at the Aberdeen Proving Grounds on Thursday, October 10. Airplanes bombed and machine-gunned targets on the ground, and in their turn were subjected to destructive fire by machine guns and vastly improved "Archies." Tanks and heavy guns showed what could be done and already has been done in the way of adapting mechanization to modern warfare. Apart from showing in a notable manner the high state of development already attained, the maneuvers were interesting in that they revealed two striking things: One was the calm way in which the civilians present apparently failed to realize that what they were seeing might eventually develop into something much grimmer than a mere show. They saw excellent target practice, but apparently failed to realize that the day may come when *they* may become the target. The other was the fact that practically the entire exhibition revolved about aircraft in one way or another.

Color in Machinery

THE development of new color finishes, together with a general tendency to brighten up life, has led to replacement of the formerly conventional black with all shades of the rainbow and some the rainbow has not. Several typewriter companies advertise machines in various colors without stating explicitly what they are expected to match. Another company manufacturing househeating devices gravely announces that color has come to the basement. In the modern kitchen the steak is about the only article that is not either yellow or blue. And, of course, it is a secret only to the general public that while the lily is not as yet painted, many of the fruits of the tree have for some time been given an artificial coloring. It was inevitable that the same tendency should ultimately affect the manufacture of machinery. In fact, some manufacturers have viewed not without trepidation the possibility of a pink lathe side by side with a sky-blue drill press and a zebra-striped shaper. It was therefore probably a wise move for manufacturers, in an effort to counteract carrying this tendency to an absurd extreme, that at the recent Cleveland Machine Tool Show it was decided by agreement among exhibitors that all machine tools should be painted a special gray, called Machine Tool Builders' Gray. The only exception to this rule was that of a manufacturer who left certain aluminum parts in their natural finish.

While welcoming this arrangement, one cannot help wondering at the same time just how long machine-tool builders will continue to stick to this resolve. Beauty obtained by a color finish is certainly only skin deep, but should there be a suspicion that it may help sell the goods, its appeal to the sales department may prove to be quite irresistible.

This matter of color, by the way—not so much in machinery, but in general—is causing a number of sleepless nights both at the production and at the distributing end of various industries. It is all right to say that room fixtures should be in green, with the idea that people who have the general color scheme of a room in green will use this particular color of room fixture. The only trouble is that there are a number of shades of green, and that two different shades may clash worse than two different basic colors. What is more is that the same color does not always show up in the same way, depending on the size of the article and certain minor variations in the method of application.

At the retailing end the use of colors has created a situation which is decidedly disturbing. The tendency of late has been toward hand-to-mouth buying, keeping inventories down to a minimum and looking for small profits on a quick turnover. Just when this system was nicely worked out, and everybody was happy or unhappy, depending on where they stood, the color scheme practically overnight forced the retailers to increase their stocks from five to seven times. What is more, the colors do not sell equally well, and, for example, in the case of an article which the writer has investigated, from five to seven blue units are sold for every red unit, and yet red units sell, which means that the storekeeper does not dare to be without them. But because of the fact that they sell slowly their storage on shelves adds to the cost, and there is a possibility of their coming to look shopworn. Since, however, the public insists on having the handle of the kitchen mop match the general color scheme of the kitchen, there is nothing to do but carry five mops where otherwise one would suffice. It has been said that the man who can grow two stalks of wheat where one grew before is a benefactor to humanity. The retailers do not consider a benefactor of humanity the one who brought about this sudden but none the less important revolution in methods of stocking their establishments. At the same time, in some lines at least, an era of transient prosperity has been created by that multiplication of production which the use of colors has introduced.

Astronautics

THE test by Opel in Germany of an airplane propelled by rockets appears to have been very impressive in spite of its short duration and somewhat inglorious end. It should not be judged on mere figures of time of flight and speed, however, because in the first place the inventor was restricted very much by certain conditions laid down by the local police. The speed, 60 m.p.h., may not be impressive when compared with the 360 miles made by Orlebar, the winner of the Schneider cup, but it must be remembered that in the first Schneider cup race the top speed was only 44-odd m.p.h.

The test as flown did not yield any information as to the comparative efficiency of the rocket and more conventional means of propulsion, but this could not have been expected from such an elementary performance. It did show, however, several extremely interesting things.

The first and most important of all is that it is actually possible to build an airplane that will fly on the rocket principle. Hitherto new methods of propulsion have not primarily supplanted those previously existing, but have created fields of their own, and come into competition with other methods only after years of development. The same may expected of the rocket method should it become fully developed. Whether or not it will actually affect flight by airplane as we now know it, remains to be seen. But if a rocket can be devised which will propel bodies through the air, it will undoubtedly find a field of application of its own. The speed developed by the Opel plane was comparatively low in absolute figures, but indicates some very interesting possibilities when considered relatively. It takes a very large expenditure of power when applied on the reaction principle to set a body in motion and then to accelerate its speed. As soon, however, as the period of acceleration has been completed and it becomes merely necessary to supply power to overcome the various resistances encountered in the case of a flying body, the consumption decreases tremendously. It is because of this fact that in a recent test a circus strong man succeeded in preventing a large airplane from starting. Had he caught a rope when the airplane was moving even at a comparatively low speed, he would have been swept away without probably retarding the motion of the plane by anything like an impressive amount. The fact, therefore, that the Opel plane made a mile and a quarter in as many minutes, would indicate that it was flying at the rate of some 100 or more miles per hour at the end of its short trip, and that again means that rocket propulsion would seem to be capable of developing extremely high speeds under properly controlled conditions. (This statement is made, however, without any reference to the matter of economy of fuel consumption and efficiency of this method of propulsion.)

There is another angle to this matter of rocket propulsion, and that is the question of engine failure, one of the bugaboos of flight today. The rocket apparently can be so arranged as to eliminate this cause of trouble. Also rockets may apparently be arranged in such a way as to retard the downward motion of the plane. While this has been done by Opel, the idea is not new, for it was proposed as early as the middle of the last century by Jules Verne in his "Trip to the Moon."

There is another rather queer angle to this matter of flight by rocket propulsion, provided it develops into a commercial success. There is no reason why the rocket airplane should not have been invented thirty years ago, as all the data required were available at that time. Had that been the case, it is entirely possible that the whole history of aeronautics would have taken another direction, and possibly the gasoline airplane engine would not have been developed at all.

Rocket propulsion must be considered in connection with the possibility of steering airplanes by radio. If it develops at all, there is no reason why pilotless, rocket-propelled planes carrying mail and goods should not be sent across the Atlantic at heights of thirty or forty miles, to be brought down at the landing fields by radio control. A paper presented by Professor Rateau before The American Society of Mechanical Engineers (Trans. A.S.M.E., vol. 42, 1920, p. 55) some years ago showed that flight at considerable heights is the most economical, and the rocket plane with its possibility of moving at speeds which not long ago would have been considered fantastic but today are as yet merely unachieved, would seem to be the answer to the problem of quick transportation over very long distances.

The Changing Motor Car

A FEW years ago statements were made to the effect that motor cars had been practically standardized in their design, and that from then on it would be the upholstery and body lines but not engineering that would sell cars. It is not surprising that this view proved to be entirely erroneous. The motor-car industry is still young enough to be thoroughly up to date, and the severe competition for business holds a warning not to rest on laurels of past performances.

Within the last year alone there have been enough changes and improvements of a more or less radical character to make it evident that the automobile of today is not going to be also the automobile of three years from now. Further, it is apparent that the field of pioneering is not past in this great industry, and what amount to radical changes are being made without hesitation when they appear to be useful.

Two companies, the Auburn and Ruxton, have put out cars with front-wheel drives. It might be mentioned in this connection that the present shape of the automobile has been given it for a peculiar reason. The proper place for the engine with a rear-wheel drive would be at the rear of the car. The early engines, however, were so unreliable that it became imperatively necessary to place the engine where it would be readily accessible, and therefore it was mounted at the front of the car under an easily removable hood instead of at the rear, under the car. This of course necessitated a somewhat inefficient transmission to the rear, which greatly complicated the operation of the car, but gave it the appearance to which every one is accustomed now. From a mechanical point of view, however, it has been obvious for a long time that if the engine is to be at the front, the drive ought to be to the front wheels. It was only the fact that the front wheels had to be used also for steering that kept motor-car manufactuers from resorting to the front-wheel drive long ago. Now, however, that at least two of them have had the courage to put the drive where it properly belongs, an analysis of the entire subject of engine location and drive will be probably undertaken in the light of the present situation, and it would not be at all suprising if it were found that the modern engine capable of running thousands of miles without any special attention, can be relied upon to go where it properly belongs, that is, in the rear, under the car. This will not only make the drive simple and efficient, but will cut off at least one-third of the length of the car, making the gasoline automobile look somewhat like an electric. Here again times have changed. A few years ago the sales departments of the automobile companies would have raised their voices in vigorous objection, stating that shortening the car by one-third would deprive it of its opulent appearance and would make a "Luxurious" look no more impressive than a "Tin Lizzie." Now, however, so difficult has the matter of parking become throughout the country that a long car is now looked upon as a nuisance, and one that would be a third shorter without losing any essential characteristics would be greatly welcomed by the public.

The gear transmission has, since the beginning of the industry, been like the poor—always with us. Some years ago a modified transmission was put out by the Chandler Motor Co., but was replaced by the standard one the next year. The first radical change in America was made by the Graham-Paige Company last year when they introduced a four-speed transmission with the fourth speed higher than the direct drive (of course, sub-transmissions giving a higher or lower ratio than normal ones have been used for a long time as, for example, in the four-wheel-drive truck). That this proved to be a step in the right direction is illustrated by the fact that several other manufacturers have adopted the same system (Durant

Packard, etc.). Experimentally, several radical methods of changing or entirely eliminating the standard gearbox are being tried out in Europe, among others being the very interesting Constantinesco system. In Europe also the Sandberg free-wheel transmission working somewhat along the lines of a similar device on bicycles is under serious consideration, while in America a car with a hydraulic transmission is privately undergoing extensive road tests, and at least three types of steam-driven buses are under development.

On the other hand, the tendency in motor-car engineering toward the use of high compression ratios—made possible by adding to gasoline such detonants as lead salts—does not seem to be gaining, and, for example, the new Cadillac is understood to have a slightly lower compression ratio than formerly.

Looking over the modern American automobile in a general way, certain facts appear to stand out. In the first place it is on the whole an extremely well-built vehicle, which is best proved by the fact that no automobile could be sold today unless it were capable of operating at 50 m.p.h. on good roads for a practically indefinite time, day in and day out. It is only natural to expect that cars capable of such a speed would have engines so highly developed as to require practically no attention. When it comes to the matter of fuel economy and efficiency, the American automobile is as wasteful as the average American himself. While gasoline (as compared with Europe) is amazingly cheap, very little effort is made toward securing the highest economy since the said average American is a person who likes to shoot forward the instant the light changes from red to green, and who is too indolent to change gears unless he just has to. He is perfectly willing to burn a couple of extra gallons of gasoline if it makes his traveling easier.

One expectation, namely, that the introduction of the balloon tire would lead to great changes in automobile design, has not been fulfilled. It was confidently expected that because of the reduced vibration due to the use of the new tires, certain automobile parts could be lightened. Coincidently, however, with the introduction of the balloon tire, the growing congestion of traffic forced the adoption of high speeds, which in turn required more rugged design, and probably prevented making those reductions of weight which these tires might have brought about.

A "New" Meaning of Fuel Economy

THINGS were simple in matters of fuel economy formerly. The heat content of the fuel was determined, let us say, in a bomb calorimeter. This gave the available B.t.u. Next, the work developed at the machine was measured and converted into B.t.u. One divided by the other gave the efficiency of conversion of fuel into work.

Things are becoming vastly more complicated today. A simple example is in the use of powdered fuel, where in addition to the heat content of the fuel and the output at the machine, the cost of pulverizing, drying, and handling the fuel must be determined and taken into consideration. The situation becomes still more complicated when an attempt is made to utilize what may be called by-products of fuel. Here not only what happens at the power plant must be determined, but also a whole range of other factors, such as the available or potential market for sulphate of ammonia, and the various classes of tar, solid residue, etc., must be known. Where low-temperature carbonization is resorted to, the field of by-products is increased still more by the creation of such materials as benzol and motor fuel, which can be disposed of only in competition with oil products. The Bergius process goes a step further and creates by-products which compete with materials apparently unrelated to fuel utilization, as vegetable oils used for soap manufacture.

The above applies particularly to coal. When it comes to oil we find also that the situation has changed considerably in the last ten years and is on the eve of still greater changes that may ultimately upset entirely the present relationship of competition between fuels.

Oil was utilized for refined products long before the large market for crude oil was created. In this respect the history of oil differs radically from that of coal, the chemist having been a vital cog in the oil industry from the start.

Until about ten years ago, however, the basis of oil treatment was fractional distillation, the various products being subjected to special purifying and, at times, decolorizing processes. When the demand for gasoline became such that normal yields, such as produced by fractional distillation, proved to be increasingly insufficient, cracking was introduced. In this process a combination of high pressure, high temperature, and presence of steam broke up certain of the heavier molecules, with the result that parts of the oil which would have otherwise gone into kerosenes, light oils, and lubricating oils were fractionally converted into the simpler forms, giving a motor fuel which, while different from the gasoline of old days both in structure and specific gravity, proved to be entirely satisfactory for properly designed motors. Cracking has gradually reached such a stage of perfection that chemists have the product of cracking stills under practically perfect control, and can, by varying the conditions of operation, convert the oil into any of the hydrocarbons that may be desired.

Within the last few months have come indications of another radical change which may upset completely the entire motor-fuel business. As has been mentioned before in the press, the Standard Oil Company of New Jersey has entered into a contract with the German Dye Trust, known usually as the I. G. (initials of two German words meaning community of interests). The I. G. controls the Bergius hydrogenation processes, and it was at first presumed that the Standard Oil Company of New Jersey was contemplating the far-distant possibility of the exhaustion of our oil resources and the use of coal as the source of motor gasoline as is now the case to some extent in Germany. It proved, however, that the Standard Oil Company of New Jersey was thinking of the present and not of the distant future, and that its intention was to apply hydrogenation not to coal but to oil, this taking the place of conventional cracking.

It has been stated officially that a unit to produce 5000 barrels per day is already under construction. No data are as yet available as to either the cost of the operation or the materials produced. It would appear, however, that Standard Oil would not have put up an expensive commercial unit unless these questions had been satisfactorily answered.

With this new development the question of fuel economy acquires a new meaning. In addition to determining the heat content of the fuel and the B.t.u. recovered at the machine end and deriving the efficiency by a simple division, today, in addition, the engineer will have to know what by-products, such as sulphate of ammonia, coke, tars, etc., he can obtain in recovery processes of coal utilization. Then he will have to take into consideration what fuels and by-products can be obtained from oil, either by cracking or by hydrogenation, and to do this he will have to determine if hydrogen is available at a certain cost. In other words, where the economy of a fuel ten years ago was determined by a simple division, today world economics must be taken into consideration. Indeed, so complicated has become this new meaning of fuel economy that a new process of nitrogen fixation might completely upset the whole economics of low-temperature carbonization, while a method capable of producing cheaper gasoline might either make coal again the king that it was a generation ago, or remove much of the luster from such portions of its crown as are still visible.

George Alfred Goodenough

1868–1929

George Alfred Goodenough

GEORGE ALFRED GOODENOUGH, professor of thermodynamics at the University of Illinois, died suddenly of heart disease at his home in Urbana on September 29, 1929.

Many generations of engineering students at the University of Illinois have come under Professor Goodenough's inspiring and kindly influence, and many graduates have testified to their appreciation of his teaching and friendly interest in their work as students, and in their careers since graduation.

Professor Goodenough's success as an engineering teacher was based upon thorough preparation in the subject which he taught, and great enthusiasm in his presentation of the subject in the classroom. More, perhaps, than this, he was a man of the broadest human sympathies. His judgment was always highly regarded, for he had the ability to present his ideas in a clear, logical, dispassionate, and convincing manner which carried with it his sincerity and honesty of purpose.

Professor Goodenough was born at Davison, Mich., on May 3, 1868. He became a student in mechanical engineering at the Michigan Agricultural College in 1887, and received the degree of bachelor of science from that institution in 1891. In 1891 and 1892 he took graduate work at the University of Michigan, and in 1900 he received the professional degree of Mechanical Engineer from the University of Illinois.

Following his graduation from the Michigan Agricultural College, he remained there for two years as instructor in mechanics. He was connected with the International Correspondence Schools of Scranton, Pa., from 1893 to 1895, preparing textbooks in various branches of engineering.

Later he became instructor in mechanical engineering at the University of Illinois, and in 1899 was appointed assistant professor of mechanical engineering. Seven years later he became associate professor of mechanical engineering, and in 1911 was appointed professor of thermodynamics. To fill a vacancy in 1909, Professor Goodenough served for two years as acting head of the Department of Mechanical Engineering.

In addition to his success as a teacher, he was recognized as one of the most productive contributors to the literature of engineering. His chief interests were in the theoretical problems of engineering science, and he devoted much of his time to the study of higher mathematics, mechanics, and thermodynamics. He was one of the foremost authorities on thermodynamics in America.

In 1908, in collaboration with Dr. E. J. Townsend, Professor Goodenough published a book entitled "First Course in Calculus," and two years later one on the "Essentials of Calculus." In 1911, his book on "Principles of Thermodynamics" was published, and it has since come to be used extensively in many of the foremost technical schools of America. In 1915, his book on "Properties of Steam and Ammonia" was published, and it is now regarded as one of the standards for use in the computations involved in steam engineering and in refrigeration.

In addition to the books which Professor Goodenough published, he contributed, collaboratively, a number of excellent bulletins to the list of those issued by the Illinois Engineering Experiment Station. Among these are: "An Extension of the Dewey Decimal System of Classification Applied to Engineering Industries," "The Strength of Chain Links," "The Properties of Saturated and Superheated Ammonia Vapor," "Thermal Properties of Steam," "An Investigation of the Maximum Temperatures and Pressures Attainable in the Combustion of Gaseous and Liquid Fuels," and "A Thermodynamic Analysis of Internal-Combustion-Engine Cycles."

Professor Goodenough also contributed to a number of standard engineering reference books, preparing a section on thermodynamics for Marks's "Mechanical Engineers' Handbook," and another for the American Civil Engineers' Handbook. In addition to the books, bulletins, and articles specifically mentioned, he contributed numerous scientific papers to the proceedings of engineering societies and to the techncial press.

However, his hours were not wholly confined to reflections upon the possibilities of the Carnot cycle, temperature-entropy diagrams, and steam tables. He enjoyed reading Dickens, Thackeray, and Scott, whose literature was a popular part of his large private library, and he was fond of music. In summer he was frequently seen on the golf course at Urbana.

Professor Goodenough attained great prominence in the eyes of the general public as arbitrator of "Big Ten" athletics, in which capacity he served twenty-three years. He was chairman of the Western Conference Faculty Committees on both athletics and eligibility.

He became a member of The American Society of Mechanical Engineers in 1919. He was a member of the Society for the Promotion of Engineering Education, and belonged to the Phi Gamma Delta, Sigma Xi, Tau Beta Pi, and Sigma Tau fraternities.

Luther B. McMillan

1891–1929

Luther B. McMillan

LUTHER B. McMILLAN was born on September 21, 1891, in the little town of Bem, Missouri, where his father was a farmer. Shortly after his birth the family moved to another farm near Anchor, Texas. His early education was that of the usual boy in a small town, where he attended the public school and later the local high school, finally entering the Texas Agricultural and Mechanical College as a sophomore in the fall of 1908, where he elected the course in mechanical engineering. Because of somewhat limited finances it was necessary for him to support himself while at college, and during successive terms he waited on table in the college mess hall, collected students' laundry, tutored at a students' summer camp, and on several occasions served on local surveying parties. During the winter of 1911 he was badly burnt in a fire in the college mess hall, the stairs collapsing when he was descending from the second floor, where valuable records had been stored.

During his college course Mr. McMillan gave indication of that calmly analytical mind which ultimately brought him recognition as one of the leaders of his profession. He was an outstanding student in the applied sciences, and although at this time he intended to make teaching his life work, such was not to be his destiny. He was graduated as a Bachelor of Science in 1911, and took graduate work in 1912 and 1913 while serving as an instructor in mechanical engineering, receiving the degree of Mechanical Engineer in 1912 and that of Chemical Engineer in 1913.

Mr. McMillan was awarded a fellowship in engineering at the University of Wisconsin during the years 1913 and 1914, and served as instructor in steam and gas engineering at that institution. He became deeply interested in developing a better method of testing commercial pipe covering, and presented a paper entitled the "Heat-Insulating Properties of Commercial Steam Pipe Covering" which won the Junior Award of The American Society of Mechanical Engineers. This paper came to the attention of the executives of the Johns-Manville Corporation, who secured his services to standardize their methods of testing thermal insulation at their Manville factory. Shortly after completing this work, he became chief research engineer for the same company, and was called upon to develop improved types of insulation, as well as to design special applications of insulation for numerous industries, among which might be mentioned the insulation of large wood digesters, insulations for open-hearth-furnace regenerators, various types of boiler-furnace insulation, and in fact insulation for any and all types of structure where the flow of heat must be kept to a minimum. While adequate and economic thermal insulation is today one of the principal considerations of the designing engineer, the work of McMillan beginning in 1916 focused attention on a subject which has had an ever-expanding growth, and he may well be considered a pioneer in placing this great industry on a strictly scientific basis.

In 1926 Mr. McMillan was made consulting engineer for the Johns-Manville Corporation, which enabled him to give even more time to research and thought on problems of heat flow, and hence to develop the underlying fundamentals of the science on a firmer mathematical basis.

In 1928 his company decided to rehabilitate the old laboratory which Mr. McMillan had established for them in 1916, with a view to building the finest research laboratory on thermal insulation which ample funds could provide. This project was nearing completion at the time of his death, and it is gratifying to note that this splendid structure will be known as the McMillan Laboratory in memory of his scientific achievements in the field of insulation engineering.

During the years from 1916 to 1929 Mr. McMillan contributed many notable papers to the scientific press, among which might be mentioned "Heat Transfer Through Insulation in the Moderate- and High-Temperature Fields," "The Insulation of Open-Hearth-Furnace Regenerators," "Selection of Insulation for Steam Distribution Systems," and "Heat Insulation in the Modern Steam-Generating Plant." He also prepared technical data for both Kent's and Marks's Mechanical Engineers' Handbooks, for the American Society of Heating and Ventilating Engineers' Guide, the Handbook of the National District Heat Association and similar publications.

Due to his recognized scientific standing in his chosen field, as well as his engaging personality and well-balanced outlook on men and affairs, Mr. McMillan attained a place of distinction in various scientific societies and organizations. Having become a member of the A.S.M.E. in 1913, he was made one of its managers as well as a member of the Council, and served with distinction on various committees.

He was also Chairman of the Insulation Committee, as well as a member of the Executive Committee of the Committee on Heat Transmission of the National Research Council, and in that capacity was instrumental in developing test codes for determining the thermal characteristics of insulations in various temperature ranges, as well as numerous other committee activities dealing with the retardation of heat flow.

Mr. McMillan was a member of, and active in, other scientific organizations such as the American Society of Heating and Ventilating Engineers, The American Society of Refrigerating Engineers, and the Society of American Military Engineers. Among his clubs were the Engineers' Club of New York, the Western Universities Club, and the Texas Agricultural and Mechanical College Club of New York.

After a trip to Europe in 1927 in the interests of his company, during which he traveled largely by air, Mr. McMillan became an ardent aviation enthusiast. He purchased his first plane in the fall of 1928, and a second and more powerful one shortly after. On August 9, he took off from the Metropolitan Airport at Newark, New Jersey, accompanied by a passenger. At an altitude of about 600 feet the airplane went into a tail spin and crashed into the adjoining meadows. Neither Mr. McMillan nor his passenger regained consciousness before death closed the chapter, and hence the cause of the accident will remain unknown. —W. V. A. Kemp.

Cleveland Meeting of A.S.M.E. Iron and Steel Division

The Third National Meeting of the A.S.M.E. Iron and Steel Division, held September 11–13, completed an arrangement of inter-society cooperation that holds out bright prospects for the future. The meeting was part of the National Metal Congress held in Cleveland during the week of September 9, and at the time of a metal exposition. Five technical groups arranged their programs as part of the congress. The leader in this work was the American Society for Steel Treating, as the exposition was under its auspices. Other groups that held meetings were the American Welding Society and two divisions of the American Institute of Mining and Metallurgical Engineers, namely, its Institute of Metals and its Iron and Steel Division.

The congress brought together at one time and place the principal technical groups representing makers and users of metals. The program of the week was splendidly arranged as the participating groups had previously coordinated it so as to have joint sessions where there was sufficient mutual interest in the papers being presented. However, each group maintained its own individuality, while actively assisting in attracting attendance for the whole program.

The several thousands who attended the technical sessions gave many evidences of their approval of the new arrangement. It is to be hoped that a convention of this nature will become an annual affair, as there seems to be a need for regularly bringing together those interested in metal working in some such manner as they were in Cleveland.

The A.S.M.E. Iron and Steel Division sponsored ten splendid technical papers which were presented at four sessions, one of which was held jointly with the American Welding Soicety and another with the American Society for Steel Treating. The Division also got under way a prospective research on heavy-duty anti-friction bearings and discussed the possible need of research in the problems of hot sawing of metals.

Both the Iron and Steel Division and the Cleveland Section are to be congratulated on the success of their efforts in regard to the arrangement and sponsorship of the Society's part of the program of the Congress.

Machine Tool Congress Meets in Cleveland

National Machine Tool Builders' Exposition Is Occasion of Well-Attended Technical Sessions

THE National Machine Tool Builders' Exposition, held in the Public Hall and Annex, Cleveland, Ohio, September 30 to October 4, inclusive, attracted to Cleveland some $5,000,000 worth of the latest production machine tools, thereby well justifying the slogan "The Greatest Machine Shop in the World," used during the promotion of this event. Interpreted by a different standard, this collection of machine tools represented between 400 and 500 carloads. The affair was unique also on account of the wide variety of tools. They ranged from tiny bench lathes, suitable for almost microscopic work, up to huge boring mills suitable for great-parts use in railway and steamship shops. Classified by the nature of their work, the tools ranged from powerful rough grinders used in snagging heavy castings, to precision grinders which will finish work to the last tenth of a thousandth, and gage this work automatically to give high production with this remarkable accuracy.

High-Speed Cutting Tools

Outstanding among the many new developments at the Exposition was the application of the new tungsten carbide cutting materials to practical production work. This material has come to the front since the last National Machine Tool Builders' Exposition two years ago. At that time MECHANICAL ENGINEERING, in its report on the Exposition, quoted the oft-repeated assertion of the machine-tool men "on the firing line" to the effect that "those steel men will have to find something new if we are going to increase production beyond the present limit—our machines have at last caught up with their high-speed steel, and we are able to burn up their tools." This was a statement which marked the end of an era of over a quarter of a century, and the makers of cutting materials were not long in meeting the challenge of the machine-tool builders. The 1929 Exposition came too soon to allow of many radically new designs intended for the sole use of tungsten carbide tools, but it did not come too soon to indicate that machine-tool builders will not require a quarter of a century to take full advantage of this material. Demonstrations of what it is to mean in increasing production and decreasing the "down time" of machines were evident on every hand. The standard machine tool of 1929 is better able to utilize tungsten carbide tools than the standard machine tool of 1899 was to utilize the pioneer high-speed steels of that day. Furthermore, the machine-tool builder of 1929 has a more open mind and a friendlier attitude toward such an innovation as tungsten carbide than had most of his predecessors of 1899. The spirit of research has taken hold in this industry, and able support is being given to it by the manufacturers of the cutting tools. The next exposition should show marked effects upon machine-tool design due to this co-operative effort of the two groups—spurred on as these efforts are by machine-tool users.

While the development of hydraulic feed mechanisms was not as marked as the 1927 exposition indicated would be the case, there were some outstanding new developments as well as highly developed older applications. The station type of machine has grown in popularity, and in these machines there has been a considerable decrease in non-productive time, as well as increase in accessibility. Such machines in big capacities were in evidence.

Any disappointment which might be felt by those who attended the Exposition because of the lack of many "revolutionary" new developments should be tempered by consideration of the fact that during the greater part of the past two years machine-tool builders have enjoyed a degree of prosperity unheard of since the hectic days of the World War. There has been little time to develop the radically new—as a matter of fact, the shops have been working nights to take care of current business, and even at that orders are being booked months ahead. This is conclusive proof of the theory that in production metal-working plants the day of the obsolete machine tool is over. This condition has been forced—even upon the unwilling—by increasing competition in the metal-working industries. This applies to the automotive industry in particular.

Technical Sessions

As the National Machine Tool Builders' Exposition brought at least 25,000 engineers, executives, and production men to Cleveland from all over the world, it gave a most unusual opportunity for technical meetings. The A.S.M.E.—through its Machine Shop Practice Division—rose to this opportunity. In collaboration with the Machine Tool Congress (a technical group affiliated with the National Machine Tool Builders' Association) and the Society of Automotive Engineers, a series of production meetings were staged which tied in with the exposition without interfering in any way with its strictly business character between the hours of 10:00 a.m and 6:00 p.m. Due to the attendance at the exposition being limited strictly to those vitally interested in production metal working, an unusually "closely tuned" audience was assured for the technical sessions.

On Monday evening, September 30, the sessions were opened by the A.S.M.E. with a paper prepared by George T. Trundle, Jr., on the general subject, "What Information Does the Machine-Tool Buyer Need From the Machine-Tool Salesman?" Mr. Trundle is president of The Trundle Engineering Company, of Cleveland, consultants in mass-production manufacturing and management, and he was able to draw from an unusual fund of experience in the purchase and recommendation of machine-tool equipment. It held up a mirror to machine-tool men in which they were able to see their selling methods as users see them, and the consideration could not have been entirely a pleasant one in some cases. That it will lead to considerable overhauling of selling methods is unquestioned. At this session the A.S.M.E. had the good fortune to have as chairman Philip E. Bliss, president of The Warner & Swasey Company, past-president of the National Machine Tool Builders' Association, and recognized authority in the marketing of machine tools. His remarks added greatly to the interest and value of the session, and he was also able to stimulate discussion due to his personal acquaintanceship with many in the audience.

The Machine Shop Practice Division of the A.S.M.E. again did the honors on Tuesday evening, October 1, with Dr. Zay Jeffries, vice-president of the Carboloy Company, as the speaker. His topic was a general one covering the development and application of tungsten carbide tools. As one of the world's outstanding metallurgists, and as one who has collaborated with the General Electric Company in the development of Carboloy, Dr. Jeffries spoke with unquestioned authority. Typical of the records cited by him was: 30,000 armatures per grind with a tungsten carbide turning tool, against 150 with a high-speed-steel tool. Again the chairman was a well-known figure in the machine-tool industry—Ralph E. Flanders, manager of the

Jones & Lamson Machine Company, Springfield, Vermont, past-president of the National Machine Tool Builders' Association, and vice-president elect of the A.S.M.E. Mr. Flanders contributed first-hand experiences in the practical application of tungsten carbide tools, and drew worth-while discussion from the audience.

On Wednesday evening, October 2, the session was under the auspices of the S.A.E., with E. P. Blanchard, of the Bullard Company, Bridgeport, Connecticut, as chairman, and Prof. Fairfield E. Raymond, of the Massachusetts Institute of Technology, as speaker. Professor Raymond's subject was "Economic Production Quantities"—this being aimed primarily at the automotive industry.

The S.A.E. likewise sponsored the session on Thursday evening, which was an open forum on the general subject of production. Four topics were discussed: "Application of Standard Machine Tools to Automobile Manufacture;" "Results in Production Due to New Features of Machine-Tool Construction;" "Synchronizing Automobile Parts at the Assembly Line;" and "Basis of Replacing Machine Equipment." A. K. Brumbaugh, of The White Motor Company, was the chairman of the session.

The last session, on Friday evening, October 4, was a Production Dinner held jointly by the A.S.M.E., the S.A.E., and the Machine Tool Congress. As a respite after a very arduous week this meeting was of a non-technical character. The toastmaster introduced as the speaker James Schermerhorn, Sr., founder of the Detroit *News*. Mr. Schermerhorn released a sheaf of humorous stories which "broke the ice," and then swung into a philosophic vein in which he saw American methods giving the world "the new in place of the old," and all this tending toward world union in the not remote future.

The doors of the Exposition closed at 6:00 p.m. Friday, to reopen on another great Machine Tool Exposition in either 1931 or 1932—this depending upon the will of the majority of the N.M.T.B.A. The consensus of opinion was that it was a remarkable and worth-while event, that it will help to maintain the present wave of domestic machine-tool replacement, and that it will give marked stimulus to American machine-tool sales abroad. The A.S.M.E. did well to encourage this project.—G. H.

Third National Fuels Meeting, Philadelphia

Domestic and Industrial Heating, Together With Smoke Abatement, Discussed in a Program on Fuels Utilization

EVER since the Society's technical activities were organized under the Professional Divisions, a new type of engineering meeting, called the National Meeting, has come into being. These national meetings, sponsored by the Professional Divisions, have been devoted to the consideration of problems in a given field. Because they have concentrated attention on a single subject and offered not only technical papers of a high order of merit but also unusual contacts between engineers of like interests, these meetings have been uniformly successful.

The Fuels Division has been a leader in the development of the National Meeting idea. Holding its first meeting in St. Louis in 1927 with a registration which justified the extent of the undertaking, following this with an even larger attendance at Cleveland last year, and now exceeding both in the recent gathering at Philadelphia, the Fuels Division has been successful in demonstrating the value of this type of meeting and the interest which is aroused by it. To say that the number in attendance at Philadelphia exceeded that which could be counted upon to attend an annual meeting of the entire Society not so many years ago, is to further attest to the importance of the event.

The Third National Fuels Meeting, under the auspices of the Fuels Division and the Philadelphia Section of the A.S.M.E., was held in Philadelphia, October 7 to 10, with headquarters at the Bellevue-Stratford Hotel. The registration exceeded one thousand. Thirty-five technical papers were presented and discussed in eleven sessions. In addition inspection trips were scheduled for every afternoon from Monday to Thursday, and for social contacts there was a smoker and buffet supper on Monday night, attended by upward of 700 men, and a banquet on Tuesday night. The ladies, who were naturally not interested in the technical sessions, were cared for in a special program of sightseeing and social activities under the very gracious supervision of the Ladies' Reception Committee, Mrs. W. F. Oberhuber, Chairman.

The features of the Third National Fuels Meeting that attracted most attention lay in the emphasis placed on the problems of fuel engineering that are not connected with the central power plant. Domestic heating, industrial heating and furnaces, smoke abatement, low-temperature carbonization, held important places on the program and provided a breadth of interest which accounted for the large attendance.

Domestic Heating Problems

At the first domestic session on Monday afternoon the fundamental problems involved and the difference between this aspect of the fuel problem and that of the industrial and central-station plant were brought out by Samuel S. Wyer, consulting engineer, of Columbus, Ohio. The complications which surround this problem are the result of the unintelligent attitude of the average householder in the matters of selection of heating equipment, design and construction of house, choice of fuel, and the manipulation of the firing of that fuel. There are so many chances of going wrong and the sources of information as to the proper procedure are so haphazard that the efforts of such meetings as this of the Fuels Division are particularly welcome. Thus the second domestic session on Wednesday evening offered to the bewildered householder, seeking light on his problem, an opportunity to have explained to him the economics of various types of heating fuels and the important subject of house insulation. The familiar anthracite and bituminous coals, so long used and so universally known to inhabitants of localities where these fuels are firmly established for house-heating purposes, were given their day in court with papers by A. F. Duemler, manager, Anthracite Coal Service, New York, and F. R. Wadleigh, consulting engineer, New York. The general subject of house heating and insulation was covered by H. B. Johns, Peoples Gas Light and Coke Co., Chicago, Ill. Gas heating was presented by M. J. Roberts, president, Roberts-Gordon Appliance Co., Buffalo, N. Y., and oil heating by S. D'Arcy Rickard, of the Rickard Engineering Co., Brooklyn, N. Y. A splendid paper on coke, by P. Nicholls, fuels engineer, and B. A. Landry, assistant chemical engineer, Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa., introduced a less-known heating fuel. Great interest, because of its novelty,

attached to the paper on electric house heating by A. R. Stevenson, Jr., and F. H. Faust, of the General Electric Co., Schenectady, N. Y. The authors described a method of using an immersion type of electric heater to heat water in a storage system. The storage of heat in the water makes possible the use of off-peak current, time-control switches being used to turn off and on the current when demanded by the characteristics of the load curve of the system supplying the current. This makes it possible to purchase electric current at the low rate of off-peak power and to improve the characteristics of the system load curve. With proper insulation of the house against excessive losses, the cost of this method of heating is greatly reduced.

Small stokers came in for considerable attention. Joseph Harrington, of Riverside, Ill., read a paper at the first domestic session on "Stokers for Apartment Houses and Office Buildings," in which he surveyed the small-stoker field and gave details of construction of some recent types of stoker for this kind of service. It was apparent that there is considerable development going on in the small-stoker field and that this type of machine has demonstrated its practicability.

The attendance at the domestic heating session of Wednesday night, which was directed at the householder, was gratifying to those who sponsored the meeting. That the program committee should attempt to get past the professional engineer to the layman in an effort to help him in the intelligent handling of a perplexing problem is an indication that engineers are realizing the excellent public service they can render in such fields.

Smoke Abatement

Contacts with the public are also made in the work of smoke abatement. Here the Fuels Division has taken a position of leadership through the papers and discussions which have been features of its national meetings, and in the work of its Smoke Abatement Committee. Here again the problem is complicated by economic and political relationships. What is technically possible of accomplishment is not economically feasible nor politically expedient. Success depends in a large measure on public opinion and insistence that offenders against the common welfare be made to mend their ways. But it becomes a different problem when the individual himself becomes the offender, when cold cash must be laid out to redesign a heating system, when competition between contractors and builders forces inadequate heating plants and small chimneys upon the unsuspecting purchasers of buildings, and when manufacturers of heating equipment supply no or inaccurate information on the performance and capacity of their product.

Contributing to the process of public enlightenment on the subject of smoke abatement, the Fuels Division continues to hold meetings and publish papers. Progress in the accurate measurement of smoke was reported at Philadelphia in two papers describing apparatus for this purpose. V. P. Griffin, mechanical operating engineer of the Duquesne Light Co., Pittsburgh, Pa., and H. V. Breisky, supply engineering department, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., described a photoelectric smoke recorder whose operation is entirely automatic. The instrument employs a photoelectric cell, operates both day and night, and is not affected by weather. A photographic smoke recorder devised by Victor J. Azbe, Chairman of the Fuels Division, and used convincingly by him in smoke determinations in St. Louis, was also described. The device is arranged so that pictures are snapped at regular intervals on a strip of moving-picture film, the camera being so located that the density of the smoke can be roughly estimated against the sky. The evidence is unmistakable, as it identifies the smoke and its density the length of the smoking period, and the offending stack as well.

Low-Temperature Carbonization

Progress in this field is necessarily slow. Reports of it are always interesting. Development is exceedingly costly. Opinion seems to be, however, that eventually coal will be processed, and that the yield of tar and gas from the low-temperature process offers more favorable inducements to its development.

At the general session on Wednesday morning, Max Toltz, of St. Paul, Minn., described the carbonization plant of the Lehigh Briquetting Co., which uses the "Luigi" process. This German process is particularly adapted to North Dakota lignite. J. McQuade, of the Ben Franklin Coal Co. of West Virginia, Moundsville, W. Va., outlined the Hayes process of low-temperature carbonization used at the plant at Moundsville, W. Va.

Industrial and Power Sessions

Progress in fuel technology has naturally advanced most rapidly in the central stations where an atmosphere of scientific investigation, coupled with an economic necessity to reduce costs to a minimum, has stimulated research and development both of method and of equipment. In the industrial field, progress has been less marked, and in certain industries waste and inefficiency have been particularly noticeable. The Fuels Division is attacking the fuel problem in these industries with the hope of bringing them more nearly on a par with fuel technology as it exists in the power industry. The papers presented at the Philadelphia meeting included one on the use of fuel in the manufacture of portland cement, by H. P. Reed, special engineer, Universal Portland Cement Co., Chicago, Ill. Victor J. Azbe spoke on the psychological aspects of the problem, and J. A. Doyle, vice-president, W. S. Rockwell Co., New York, on "Economics of Industrial Heating Practice."

The afternoon session was devoted to a discussion of electricity, gas, and oil for industrial heating purposes. The discussion convinced one that the economics of the choice of heating medium, if not also the technical aspects, is rather involved and that a good salesman has an advantage over a poor one.

The power sessions at Philadelphia were devoted chiefly to two subjects, stokers and water-wall furnaces. Apparently the lion and the lamb have lain down together in the fuel-firing field, for even so genial a presiding officer as Nevin E. Funk was unable to invoke the spirit of controversy which has usually made meetings of stoker men so stimulating. Better fortune attended the more academic subject of water walls, ably presented by Ollison Craig, of the Riley Stoker Co., who recommended the consideration of each case of water walls on its own merits, and showed that the expense of water-cooled furnace walls is justified only through savings in coal and cost of equipment. J. S. Bennett and P. N. Oberholtzer of the American Engineering Co., Philadelphia, presented a paper on the "Economics and Design of Water-Cooled Furnaces," in which they related the experiences of one manufacturer in operating and designing water-cooled furnaces for underfeed stokers. J. W. Pierson, of the Commonwealth Edison Co., Chicago, gave an excellent paper on "Effect of Fouling on Boiler Efficiency."

Mention must be made of the excellent services to the Society of Prof. R. H. Fernald, Director, Department of Mechanical Engineering, University of Pennsylvania, who delivered the opening address, on "The Fuel Engineer, His Training and Work," who acted so graciously as toastmaster at the banquet, and who presided over the symposium on domestic heating on Wednesday evening. The local committee, of which Howard A. Hoffer was the energetic chairman, the various sub-committees of the Philadelphia Section, and the committees of the Fuels Division acquitted themselves splendidly in a most successful meeting, and deserve the gratitude of all those fortunate enough to attend.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Introduction to Theoretical Physics

Introduction to Theoretical Physics. Leigh Page, Ph.D. D. Van Nostrand Company, Inc., New York, N. Y., 1928. Cloth, 6 × 9 in., 588 pp., 201 figs., $6.50.

Reviewed by E. C. Blake[1]

PAGE'S "Introduction to Theoretical Physics" is designed for beginning graduate students who must get practice in tying up mathematical symbolism with physical ideas if they are to grow with the sciences of physics and mathematics. The book makes use of the vector method, and it is surprising how much space can thus be saved. One has only to compare the space needed in the text on the gyroscope, for instance, with that used by Gray in his excellent treatise on that subject to see what concentration is possible. The wise teacher must, however, make sure that the physical ideas are no less clear than they would be by the longer dynamical methods.

After an introduction on vectors and vector operations the book treats in Part I of the usual dynamics of particles and of rigid bodies, followed by a chapter on the dynamics of deformable bodies, with the underlying ideas of elasticity. Then follows a chapter on advanced dynamics, covering Lagrange's equations and the Hamiltonian function, followed by the development through contact transformations of the Hamilton-Jacobi equation, so useful in modern spectroscopy.

Part II treats of the hydrodynamics of perfect and of viscous fluids, including vortex motion and a dynamical theory of tides. In the chapter on viscous fluids the author includes the problem of the slow motion of a sphere through a viscous medium and its relation to the practical problem of determining the charge on the electron by the oil-drop method.

Part III contains short chapters on classical thermodynamics, statistical mechanics, with the classical principle of equipartition as well as the quantum principle of energy partition, followed by a brief presentation of the kinetic theory of gases.

Part IV, on electromagnetism, contains many of the laws of electrostatics and magnetostatics found in Maxwell's great treatise. Electric currents and Ampere's theory of magnetism are treated by the vector method. The classical theory of electronic conduction in metals is briefly presented, but the limitations of that theory are not given. There are included also the elements of classical electromagnetic theory and the special principle of relativity. The Compton and normal Zeeman effects and black-body radiation are topics in Part IV worthy of special mention.

The last part of the book, Part V, after briefly summarizing the principal laws of geometrical and physical optics, presents some of the more important applications of Bohr's theory of spectra, together with its limitations.

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The book is well gotten up and will no doubt meet a long-felt demand. In fact, the first edition was rapidly exhausted, and only a few weeks ago a second impression had to be struck off. A good feature of the book is the interspersing of problems at proper intervals.

The student of modern physics who masters Professor Page's book will find himself well prepared for taking the next step in modern theoretical physics, viz., the mastery of normal functions, including the method of polynomials, then of Riemann geometry, tensor analysis, and transformation theory, all so useful in the new wave mechanics. Students of mechanical engineering can ill afford these days not to make serious effort to understand the new physics of matter and energy.

Engineering Education in the United States and Europe

A Comparative Study of Engineering Education in the United States and Europe. Bulletin No. 16 of the Investigation of Engineering Education carried out under the auspices of the Society for the Promotion of Engineering Education. By Wm. E. Wickenden. Lancaster Press, Inc., Lancaster, Pa., 1929. Paper, 6 × 9 in., 275 pp. Price $0.40.

Reviewed by R. L. Sackett[2]

BULLETIN No. 16 of the Investigation of Engineering Education, carried on under the auspices of the Society for the Promotion of Engineering Education, gives the historical development of engineering schools in Europe and America, France being the pioneer. In 1747, the first steps were taken which led to the École des Ponts et Chaussées. It was followed by a variety of other French institutes. Germany began her remarkable career in technical education by organizing an academy in Saxony in 1765. Up to 1800 "there was no school of applied science in the English-speaking world."

The necessity for an organized system of highways and highway construction led France to found its first engineering school. In England, Telford and Macadam became leaders in highway construction during the continuance of the apprenticeship and tutelage system of education. Dr. Wickenden points out that the persistence of this system and a suspicion of "hypothetical engineers" and science in general has been (and still is) an obstacle to the development of technical education.

In spite of social and industrial difficulties, England has developed a system of technical institutions of high order, supplementing Oxford and Cambridge by such universities as Manchester, Birmingham, Leeds, Sheffield, Liverpool, Bristol, and others. In addition, technical schools of a high order

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known as "polytechnics" have been developed, especially in London, for instruction "in the principles of science and art applicable to industries and in the application of special branches of science and art to specific industries or employments" (Act of 1889). The polytechnics are intermediate to the trade schools on the one hand and the technical universities on the other. These constitute a valuable training for skilled trades and engineering practice, the importance of which is not yet recognized in the United States. The chief difficulty to their development in England was the absence of a system of public education, which was not remedied until 1876, and even then the "leaving age for the great majority was 12 or 13" years.

The report points out that The Institution of Civil Engineers, founded in 1818, and later the Institution of Mechanical Engineers, founded in 1847, have been profound factors in encouraging technical education of various levels in Great Britain. In the United States there has been little coordination between the technical professional engineering societies and the technical universities and polytechnic institutes. The four founder societies have recognized the Investigation and have cooperated in its advancement. This, it is hoped, is an omen of an enlightened interest in and contact with engineering education.

In Germany, the power of science when applied to industry was emphasized at the beginning of the nineteenth century. A strong program of secondary education laid a firm foundation for the creation of *technische hochschulen*, and later of engineering instruction in the universities and of research. These counterparts of technical education made Germany an industrial world power.

The report quotes Charles Gide, an eminent French sociologist, who said: "It is technical education, patiently pursued, conscientiously assimilated, which has been for Germany an arm more powerful than the spirit of enterprise of the English and the artistic feeling of the French. She owes to it her admirable commercial and industrial advance."

Dr. Wickenden traces the history of engineering education in the United States, the development of types of technical instruction here and abroad, and emphasizes the variety to be found in France, Germany, and England.

Curricula, methods of instruction, and fees are compared. Europe is devoting more time to the study of and instruction in management. As a rule fees are lower abroad.

On the subject of university research in engineering fields, Dr. Wickenden says: "It is a fair generalization that in matters of technical research our institutions are far in advance of those of France and other Latin countries, on a par with Great Britain, and definitely behind Central Europe. Parity with Great Britain, however, is not an occasion for boasting when the vastly greater scale of our university organization is considered. It is only in the last two or three decades that research has been regarded as more than an incident in the work of our engineering colleges. Our backward state, despite relatively heavy expenditures, is probably an inevitable phase of early effort. There are still relatively few men of high research capabilities in our professorial chairs; industry has requisitioned many of the most fertile for her own fast-growing research establishment; and until quite recently there has been far greater incentive to textbook writing and to incidental practice than to research. Research personnel cannot be improvised; that of the German institutions is the product of a century of cultivation and selection, backed up by a powerful tradition. . . ."

The report is a model of thoroughness, contains valuable information for the individual and the professional societies, and treats all countries and types of engineering training fully and fairly. The evaluation of American technical education is just and not conducive to conceit.

Books Received in the Library

Aerial Navigation and Meteorology. By Lewis A. Yancey. Second edition; enlarged. Henley, New York, 1929. Cloth, 7 × 9 in., 316 pp., illus., diagrams.

The work of a practical navigator and experienced aviator, this book is intended to give a good working knowledge of the elements of navigation and meteorology in easily understandable form. Contains also the Air Commerce Regulations of the United States and a glossary.

Aluminium, die Leichtmetalle und Ihre Legierungen. By Paul Melchior; im auftrage der Deutschen Gesellschaft für Metallkunde. V.D.I. Verlag, Berlin, 1929. Cloth, 6 × 8 in., 280 pp., illus., tables, diagrams, 15 r.m.

A handbook on aluminum and magnesium and their alloys, which aims particularly to meet the practical needs of engineers. The metallography, chemistry, and physical properties of the metals are described; methods of shaping, finishing, and joining are explained, and the uses of the metals and alloys for various purposes are related. Standards of various countries are given. Much scattered scientific information is made conveniently accessible to machine builders.

Application of Science to the Steel Industry. By W. H. Hatfield. American Society for Steel Treating, Cleveland, 1928. Cloth, 6 × 9 in., 154 pp., illus., diagrams, tables, $2.50.

Dr. Hatfield reviews recent advance in our knowledge of steel making, with especial reference to British practice. The manufacture of steel, its manipulation and treatment, special steels that resist wear, heat, and corrosion, are discussed in an illuminating manner.

Blast Furnace Practice. By Fred Clements. Vol. 2. Benn, London, 1929. Cloth, 8 × 11 in., 509 pp., illus., plates, diagrams, 63s.

The second volume of this exhaustive treatise is devoted to the design and equipment of blast-furnace plants. Furnace design, linings, charging methods and gear, crude-gas systems, stoves, the handling of iron and slag, auxiliary machinery, and pyrometers are discussed. Examples of current practice from all parts of the world are given in encyclopedic fashion. Designers, engineers, and operators will find the book useful.

The Creep of Steel at High Temperatures. By F. H. Norton. First edition. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 90 pp., illus., tables, diagrams, $3.

The investigations reported here were carried out at the Massachusetts Institute of Technology, at the request of the Babcock & Wilcox Co., to provide engineering data on safe stresses for steels at the higher temperatures. After reviewing previous methods and results, the author describes his apparatus, gives the results of investigation of steels at temperatures above 1000 deg. fahr., and discusses his results.

Dieselmaschinen IV. V.D.I. Verlag, Berlin, 1929. Paper, 8 × 12 in., 103 pp., illus., tables, diagrams, 6 r.m.

Contains the papers upon Diesel engines published in the *Zeitschrift des Vereines deutscher Ingenieure* during 1927 and 1928. The papers cover a wide variety of topics. Brought together, they form a handy review of the work of those years.

Druckrohrleitungen der Wasserkraftwerke, Entwurf, Berechnung, Bau und Betrieb. By Artur Hruschka. Springer, Berlin, 1929. Paper, 6 × 9 in., 283 pp., illus., tables, diagrams, 23 r.m.

This book aims to review the theoretical and practical considerations that govern the design of high-pressure water conductors for power plants, the methods of construction that have

become generally accepted, and some of the especially noteworthy pipe lines of the world. The book discusses the theory, design, and construction of pipe, pipe fittings, and pipe lines, and the operation and maintenance of the latter fully and practically. A table of important lines is given, as well as an extensive bibliography.

L'Enfant and Washington, 1791–1792. Edited by Elizabeth S. Kite. (Institute Francais de Washington. Historical documents, cahier 3.) Johns Hopkins Press, Baltimore, 1929. Bound 8 × 11 in., 182 pp., plate, $3.

Here are brought together in chronological order all the existing documents upon L'Enfant's work in planning the city of Washington. They give an interesting picture of his labors, the difficulties that he met, and the reason for his final dismissal. Ambassador Jusserand's introduction is a fine account of L'Enfant's life.

Evaporating, Condensing and Cooling Apparatus. By E. Hausbrand. Translated from second revised German edition by A. C. Wright. Fourth English edition revised and enlarged by Basil Heastie. Van Nostrand, New York, 1929. Cloth, 6 × 9 in., tables, diagrams, $8.

In preparing this edition, the reviser has rewritten the chapters dealing with the flow of steam, water, and air through pipes and has recalculated the tables in the light of recent experiments at the National Physical Laboratory. He also includes a summary of recent work on heat losses through convection and radiation, and has added a chapter on modern evaporating plants. These changes, with the thorough revision of the tables and general text, make the book again valuable to designers of this apparatus, who will find here many formulas and tables of great use to them.

Fahrzeug-Getriebe. By Max Süberkrüb. Springer, Berlin, 1929. Paper, 6 × 9 in., 190 pp., illus., diagrams, 24 r.m.

The author endeavors to provide the data necessary for comparing the various gearing used in locomotives and automobiles. The fundamental requirements of these gears are first discussed and their elements examined. A large number of individual gears of all kinds are described, and their suitability for various purposes examined from mechanical and economic points of view. A valuable monograph on transmission gearing.

Farm Machinery and Equipment. By Harris Pearson Smith. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 448 pp., illus., tables, $3.25.

After a brief introductory discussion of the principles of farm machinery, the various types of farm machines are described, and their construction, operation, and efficiency discussed. The entire field of American usage is covered.

Foundry Practice. By R. H. Palmer. Fourth edition. John Wiley & Sons, New York, 1929. Cloth, 5 × 8 in., 450 pp., illus., tables, $3.50.

Intended primarily as a course in foundry practice, this book illustrates methods for various kinds of molding, from the simplest to the more difficult, and discusses mixtures, melting, furnaces, cleaning of castings, etc. The new edition incorporates recent advances in methods and equipment.

Foundrymen's Handbook. Second edition. Penton Publishing Co., Cleveland, 1929. Bound, 6 × 9 in., 574 pp., illus., diagrams tables, $6.15.

A collection of formulas, tables, weights, specifications, and general data upon foundry practice, compiled from the Data Sheets published in *The Foundry*. A great mass of practical information is included, carefully classified and indexed, making the book a valuable one for ready reference. The new edition is much enlarged.

Hochdruckdampf II. Sonderheft der V.D.I. Zeitschrift. V.D.I. Verlag, Berlin, 1929. Paper, 8 × 12 in., 171 pp., illus., diagrams, 6 r.m.

This volume brings together the more important papers on high-pressure steam which have appeared in the *Zeitschrift des Vereines deutscher Ingenieure* during the last five years. The papers discuss a variety of questions connected with the production and use of steam at high pressures, such as modern methods of generation, the influence of high pressures and temperatures upon engine design, and the transformation in industrial practice caused by the introduction of higher pressures.

Rohrbrunnen. By Erich Bieske. R. Oldenbourg, Munich and Berlin, 1929. Cloth, 7 × 10 in., 214 pp., illus., diagrams, 14 r.m.

This, the author states, is the first work devoted exclusively to deep wells as a source of water supply. The subject is treated practically, in detail, on the basis of long personal experience. Drilling machinery and methods, casing, filters, location of wells, pumping, maintenance, costs, etc., are discussed.

Die Sicherung Geschweisster Nahte im Auftrag des Schweizerischen Vereins von Dampfkessel-Besitzern, hrsg. von E. Höhn. Springer, Berlin, 1929. Paper, 6 × 9 in., 100 pp., illus., diagrams, 3 r.m.

The author, as chief engineer of the Swiss Society of Steam Boiler Owners, has long been occupied with investigations of various factors controlling the safety of steam boilers and pressure vessels. The present pamphlet gives the results of investigations of the effect of transverse and longitudinal welded butt straps in strengthening electric and autogenous welds.

Statics, including Hydrostatics and the Elements of the Theory of Elasticity. By Horace Lamb. Third edition. University Press, Cambridge, 1928. Macmillan Co., New York. Cloth, 6 × 9 in., 357 pp., 12s 6d; $4.25.

Professor Lamb's text, based upon his course at the University of Manchester, is distinguished by its easy mathematical style and its lucid presentation of the subject. Prominence is given to geometrical methods, particularly those of graphic statics. The new edition has been revised and partly rewritten.

Theory of the Gyroscopic Compass and Its Deviations. By A. L. Rawlings. Macmillan Co., London and New York, 1929. Cloth, 6 × 9 in., 191 pp., diagrams, tables, $3.50.

Dr. Rawlings, who has been intimately connected with the development of the gyro compass, here attempts to explain its theory in a way that can be understood by those who manufacture and use it. The forms in commercial use today are described quite fully, and considerable space is devoted to the claims of rival inventors.

Vielschnittbänke, Ihre Konstruktion und Arbeit. By Max Kurrein. Verlag der Werkzeugmaschine, Berlin, 1929. Cloth 7 × 10 in., 114 pp., illus., diagrams, 15 r.m.

The construction of multi-cut lathes occupies one-half of this book. The elements of automatic lathes are described in detail and illustrated by photographs and drawings of many modern types, chiefly German and American. The second half of the book describes examples of tooling for various kinds of work.

Werkzeuge und Einrichtung der Selbsttätigen Drehbänke. By Ph. Kelle. Springer, Berlin, 1929. Paper, 6 × 9 in., 154 pp., illus., diagrams, 15 r.m.

Describes tooling methods for turret and automatic lathes. Chucking, tools, tooling, calculation of output, exactness, and tolerances are discussed practically, with many examples.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in the current issues of the Aeronantical Engineering, Applied Mechanics, Hydraulic, Machine-Shop Practice, Management, Petroleum, and Printing Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced when completed, in later issues of "Mechanical Engineering."

AERONAUTICAL ENGINEERING PAPERS

Design, Construction, and Handling of Non-Rigid Airships. By Thomas L. Blakemore, J. F. Boyle, and Norman Meadowcroft. [Paper No. AER-51-6]

After discussing the fabric used for airships and its rubberization, the authors describe the method of fabricating an envelope. They then take up the inflation, assembly, and rigging of non-rigid ships and their commercial possibilities. Following this they deal in order with ground handling; requirements for mechanical handling equipment and status of its development; and with mooring masts and systems.

Airports and Airport Engineering. By John Bonforte. [Paper No. AER-51-7]

In this brief paper the author submits a definition of airport engineering and enumerates the qualifications of an airport engineer. He then rapidly discusses the problems confronting the airport engineer, dealing with them under the respective headings of selection, planning, construction, and lighting.

Type Testing of Commercial Airplane Engines of Medium Power. By H. K. Cummings. [Paper No. AER-51-8]

The author gives details of the procedures prescribed by the U. S. Navy Department, the British Air Ministry, and the U. S. Department of Commerce for determining the performance characteristics of new types of airplane engines and for determining their reliability. He includes a list of 23 engines which had received approved type certificates prior to May 15, 1929.

Development of Welded Aircraft Construction. By S. C. Clark and W. I. Gaston. [Paper No. AER-51-9]

In this paper the authors point out that steel tubing is coming into common use for fuselage construction and that with this there is a trend toward general use of welding. It is desirable to establish standard designs for welded joints, and to this end further research is needed. Suggestions are made for improvements in welding practice that will add safety and insure uniformly well-made welds.

Relative Merits of Various Types of Wing Structure in Monoplane Design. By George W. DeBell. [Paper No. AER-51-10]

With reference to wing design the author divides airplanes into four classes ranging from the sport type (under 2500 lb.) to the large transport (over 20,000 lb.), and then presents an analysis of the types of spar structure adaptable to these different classes.

Radio Developments Applied to Aircraft. By J. H. Dellinger and H. Diamond. [Paper No. AER-51-11]

In this paper the authors point out the need for equipment and methods that will reduce the weather hazards of air transportation. Radio offers great possibility as an aid to flight. Research work carried on by the Bureau of Standards has led to developments through which weather and landing conditions can be communicated to pilots while in flight, and through course navigation, flying can be done satisfactorily regardless of fog. Many interesting applications of radio to aircraft are described.

Airplane Fuel and Lubricants. By C. K. Francis. [Paper No. AER-51-12]

The author presents a wealth of detail in regard to gasolines and lubricating oils for airplane engines. Paraffin-base oils, he states, have proved to be superior to asphalt-base oils because of their ability to resist heat. In breaking in new engines blends with castor oil are advantageous because of the tendency of aluminum pistons to cut and freeze owing to initial growth of the aluminum. Natural gasoline is to be preferred for airplane use as it not only gives the maximum speed and power, but because its higher gravity gives the plane a wider cruising area for the same weight carried. Averages of figures for 80 million air-miles flown show fuel consumption of 1 gal. for every 4 miles, and 1 gal. of lubricating oil for 70 miles.

Air-Mail and Express Traffic. By R. W. Ireland. [Paper No. AER-51-13]

The organization of most of the air-transport lines of the country is patterned somewhat after the organization of the railroads, as it is only a newer and faster method of moving persons or things. The number of air-transport lines is increasing with each year. The twenty-five existing lines are supported by private capital. An average of 42,000 miles is flown over these lines every 24 hours. The Department of Commerce has completed the lighting on over 9000 miles of the 20,000 miles of airways now in operation.

Landing Speed of Airplanes. By John G. Lee. [Paper No. AER-51-14]

Results of a large number of wind-tunnel and flight tests on the maximum lift of wings are presented, analyzed, and compared. Curves are given showing the relationship between the shape and lift of wings and for the landing speeds obtained with different wing loadings and lift coefficients. The subjects of sinking speeds, landing impacts, and the effect of flaps and slots are discussed in relation to landing speed and the general problem of easy landing.

Air Transport in New England. By Sumner Sewall. [Paper No. AER-51-15]

With few airports available, and still fewer natural landing fields, the author believes the solution of the problem is the development of an amphibion plane suitable alike for landing on the lakes, streams, and harbors of the country, as well as on ice and snow in winter.

Ball and Roller Bearings in Aircraft. By Frederick W. Mesinger. [Paper No. AER-51-16]

Bearings finding favor in aircraft construction include the straight cylindrical roller bearing, which is selected where heavy radial loads are imposed and where definite space limitations control the size of the bearings; radial ball bearings of the closed-race type, used where ordinary radial loads and thrust loads are encountered, and the open type, used in applications where advantage can be taken of the easy assembly feature of this type of bearing and its high degree of precision. The author examines in some detail the more interesting mountings that have been definitely adopted.

Commercial Aircraft Engines of Medium Power. By Richard M. Mock. [Paper No. AER-51-17]

According to the author, the proper engine for a medium-power plane should develop from 60 to 200 hp. and be air-cooled. Engines should have interchangeable mountings to facilitate installation in various types of planes. The paper includes a table of manufacturers' specifications on engines available for commercial use.

Aerial Photography Engineering. By E. R. Polley. [Paper No. AER-51-18]

Aerial photographic surveying is described, and its advantages over ground work are given. Maps may be made with almost perfect detail and at far less cost of time and money than required by survey work in the usual manner. The methods by which the many overlapping photos are taken and then assembled in the scale map are outlined, together with the supplying of stereoscopic photos for studying the contour and physical features of the terrain. Maps made from the air have a value to municipalities in zoning and taxation problems, and to counties and states for highway, park, reforestation, and waste-land activities.

Application of Advanced Methods to Airplane Structural Analyses. By Dr. Michael Watter. [Paper No. AER-51-19]

This paper urges the necessity of wider use of finer methods of structural analysis. It illustrates the importance of use of advanced methods not only from standpoint of structural safety, but also as a means of evolving new forms.

It outlines briefly some results from the author's experience, and in connection with the desirability of finer methods urges closer coordination between aerodynamical facts and structural requirements.

Certain present requirements are criticized and a suggestion is made to revise the conception of load factors in their relation to individual members.

APPLIED MECHANICS PAPERS

The Mechanics of Plate Rotors for Turbo-Generators. By J. P. Den Hartog. [Paper No. APM-51-1]

With the rapid development of turbo-generators during the last five years, the length of the rotors has practically been doubled. More or less elaborate mechanical calculations, especially of the "plate rotors," have been evolved and experiments have been carried out in order to place the design of this apparatus on a rational basis. In this paper some of the mechanical problems which have come up in connection with this development are discussed in detail.

Tests on Belleville Springs by the Ordnance Department, U. S. Army. By D. A. Gurney. [Paper No. APM-51-2]

Belleville springs are dish-shaped spring washers which have long been used where relatively large load capacity, small deflection, and a limited closed height are necessitated by other controlling features of design. Recent demands for larger Belleville springs than those previously used disclosed the absence of any reliable design data; and the investigation presented in the paper was undertaken to supply this lack of information. A formula for use in their design, based on the investigation, is given.

Journal Running Positions. By H. A. S. Howarth. [Paper No. APM-51-3]

The classic theory of bearing lubrication propounded by Reynolds and extended by Sommerfeld has shown that when a journal runs in a full bearing with a complete film, the journal center will run opposite the center of the bearing when the journal load acts directly downward against the bearing. The classic theory has, the author believes, also shown that the journal will never rise higher than opposite the bearing center, if the bearing measures 180 deg. long and if the load line bisects that angle.

Consequently the impression has gained ground that under no circumstances will the journal rise higher than the bearing center in any clearance bearing—if the classic theory is correct. The present investigation was therefore undertaken to find out whether that current impression was reasonable.

The result of the author's analysis proves that the current impression is erroneous. The journal may run with its center higher than that of the bearing, if the load, speed, viscosity, clearance ratio, and α/β ratio are compatible therewith. This must be so if the classical theory is correct.

The analysis indicates that the load direction upon a partial bearing has an amazing influence upon the running position of the journal. It also indicates that no matter how high above the bearing center the journal may run at any finite speed, it will return to run concentric with the bearing at infinite speed.

Combustion at High Pressures. By L. C. Lichty. [Paper No. APM-51-4]

In the author's experiments hydrogen-air mixtures ranging from $1 H_2 + 0.85$ Air to $1 H_2 + 6.5$ Air were investigated, first, by varying the length of combustion chamber, holding the initial temperature constant at 80 deg. fahr., and second, by varying the initial temperature from 80 to 400 deg. fahr., holding the length of combustion chamber constant. Records were obtained from which the effect of mixture on maximum pressure was studied, as well as the effect of surface-volume relationships on maximum pressure, effect of mixture on time of pressure rise, rate of flame propagation, heat loss during pressure rise, etc.

Fatigue and Corrosion-Fatigue of Spring Material. By D. J. McAdam, Jr. [Paper No. APM-51-5]

In this paper the author discusses respectively the relation of the endurance or fatigue limit to other physical properties; the endurance properties of steels, nickel-copper alloys, and copper-tin alloys; the effect of varying the position of the endurance range within the elastic range; the effect of abrupt changes of section; the corrosion fatigue of steels, nickel-copper alloys, and copper-tin alloys; metallic coatings for spring material; and the effect of cycle frequency on fatigue and corrosion fatigue. An extensive and valuable table of physical properties of steels and non-ferrous alloys is included in the paper.

Combined Stresses in Thick-Walled Cylinders. By Earle B. Norris. [Paper No. APM-51-6]

The paper describes some tests which were made on 11 thick-walled cylinders of high-quality gun steel, ranging in bore from 3 in. to 9.5 in., and with ratios of outside to inside diameters of 1.5, 2, and 3. To the author the evidence seems to warrant the conclusion that the maximum-strain theory of St. Venant is correct for cases of tension and compression in mutually perpendicular planes where the tension stress is the greater of the two.

Short Flanged-Tube Cantilevers Under Concentrated Radial Load. By Wendell P. Roop. [Paper No. APM-51-7]

The author gives results of tests of a short thin-walled tube fixed at one end and reinforced at the free end by a flange, which was loaded radially at the free end. The elastic deflections and ultimate strength were observed, and the author devises formulas for their expression. The strength and stiffness of an elastic ring are discussed mathematically in an appendix.

Telephone-Apparatus Springs. By J. R. Townsend. [Paper No. APM-51-8]

In this paper the author deals with the principal types, which may be classified as sheet non-ferrous metal springs, clock-spring-steel springs, and helical (music wire) springs, stating the properties desired of these springs. Data on the mechanical properties of non-ferrous sheet spring materials and of clock-spring steel are given in the form of tables.

The Piston-Crosshead Motion of the Oilgear Pump. By Elek Benedek. [Paper No. APM-51-9]

The Oilgear pump is a variable-delivery radial pump which converts mechanical power into hydraulic power in the form of an oil stream under pressure. An oil motor is used to reconvert the power into mechanical form and apply it to the work to be done. For services requiring greater power than the applications so far made, improvements are needed which will reduce noise and vibration. The present paper derives equations for determining the path, velocities, and accelerations of any point in the piston-crosshead unit of the Oilgear pump, as investigation has shown that an accurate knowledge of the accelerations of the mechanical parts and of the oil in the cylinders and ports is necessary as a basis for further improvements in design.

Deflection of a Round-End Strut Subjected to a Constant Moment or a Transverse Force at the Middle. By James E. Boyd. [Paper No. APM-51-10]

When a loaded strut is subjected to a transverse force or any other bending moment in addition to that caused by the longitudinal load, the additional deflection is greater than it would be if the additional moment were applied to the strut as a beam. In this paper an equation is derived for the deflection of a loaded round-end strut subjected to a transverse force at the middle and a moment which is constant throughout the length. To experimentally investigate the theory, tests were made on a cold-rolled steel strut 60 in. long and 1.25 in. in diameter with transverse forces of 5 lb. and 10 lb. at the middle. Measurements were taken for a series of longitudinal loads with positive, negative, and nearly zero eccentricity. Other experiments were made with a constant moment alone.

For both sets of experiments the additional deflections agree so closely with the theory as to leave no doubt in regard to the validity of the equations.

For the application of the theory, a formula which gives the ratio of the additional deflection of a loaded strut to its deflection as a beam in terms of the ratio of the longitudinal load to Euler's critical load is derived for each of these two moment conditions. A similar formula is derived for a uniformly distributed transverse force. Tables and curves are given which show the relation of these ratios with sufficient accuracy for practical computations.

Design of Columns of Varying Cross-Sections. By Dr. A. Dinnik (Translated by M. Maletz). [Paper No. APM-51-11]

In designing compression members for use as booms and masts for derricks, connecting rods for engines, airplane struts, etc., it is de-

sirable to reduce their weight to a minimum and yet maintain stability. To meet these conditions it is the usual practice to make these members with a varying cross-section.

This paper develops and presents formulas and coefficients of stability which will enable the designer to select the proper section for a given column without setting up the differential equations and their integration.

CALCULATION OF FLYWHEELS FOR AIR COMPRESSORS. By H. R. Goss and H. V. Putnam. [Paper No. APM-51-12]

The authors present a short history of the application of low-speed synchronous motors direct connected to ammonia compressors. It is shown how the use of *XY* curves has brought about a practical solution of the flywheel problem and how in practically all present-day cases the necessary flywheel effect can be incorporated in the rotor of the synchronous motor. A short history of the application of synchronous motors to air compressors is also given, and the special problems encountered due to the unbalanced weights of reciprocating parts and to part-load operation of air compressors are discussed.

A derivation of the fundamental differential equation of the *XY* curve is given and a simple method presented for its solution. An example illustrating the method of making *XY* curves is given. Curves and data are given which materially reduce the labor involved in making *XY* curves. A set of eight *XY* curves for two-cylinder double-acting two-stage air compressors is included. These curves cover full-load, no-load, and six different part-load conditions. A second set of two *XY* curves is presented covering full-load and no-load operation for single-cylinder double-acting single-stage compressors.

The paper has two appendixes. Appendix No. 1 presents formulas for calculating the theoretical indicated horsepower for single- or for two-stage multi-cylinder compressors. Appendix No. 2 presents methods of calculation of the theoretical torque curves for compressors. An expansion for the inertia torque due to the reciprocating parts of a compressor is given.

DESIGN OF ELLIPSOIDAL HEADS FOR PRESSURE VESSELS. By T. W. Greene. [Paper No. APM-51-13]

This paper, after dealing theoretically with the stresses set up in cylindrical pressure vessels provided with ellipsoidally dished heads, gives results of tests made on a propane storage tank 7 ft. in diameter, 38 ft. 4 in. long, and designed for a working pressure of 200 lb. per sq. in., the heads being ellipsoidal with a 2-to-1 ratio of axes. From these results the author concludes that (1) heads with dish and large knuckle radii proportioned to closely approximate true ellipsoidal shapes with a ratio of axes of 2 to 1, are far superior to the flat dished heads with small knuckle radii commonly used in pressure vessels; (2) that the stress distribution in such heads closely approximates that set forth by theory, and that in consequence the formulas presented in the paper can be safely used for design.

ANALYSIS OF THE UNIFORM-RISE AND UNIFORM-PRESSURE-ANGLE CAM CURVES. A Method of Designing Cams by Means of Prepared Charts. By R. F. Mallina. [Paper No. APM-51-14]

The practical design of cams sometimes requires a thorough investigation of the practical limits to which a designer may go without greatly changing the leverage ratio from cam shaft to cam-lever shaft and without putting unnecessary strain on the follower stud. It is the purpose of this paper to point out methods of obtaining such limits and to provide tables and charts which will enable the draftsman to determine certain cam curves with a minimum of effort. The results of this investigation are as laid down in two appended charts.

FRICTION OF JOURNAL BEARINGS AS INFLUENCED BY CLEARANCE AND LENGTH. By S. A. McKee and T. R. McKee. [Paper No. APM-51-15]

An investigation at the Bureau of Standards is described, the object of which was to determine the effects upon the frictional resistance of small-bore full-journal bearings of changes in the length-diameter and clearance-diameter ratios. A journal-bearing friction machine provided a method for measuring the frictional resistance when operating under different conditions of load on the bearing, speed of the journal, and viscosity of the lubricant. By a suitable correlation of these factors a measure of the effects of changes of clearance and length with bearings of the same diameter was obtained. The results indicate that changes in the length-diameter ratio as well as in the clearance-diameter ratio have marked effects upon the frictional characteristics of journal bearings in normal operation. Suitable corrections to a theoretical equation for journal friction are derived from these experiments for bearings of all normal clearances and lengths. In the conclusion, further steps toward a more complete understanding of journal-bearing performance are indicated.

STRESS DISTRIBUTION IN ROTATING DISKS OF DUCTILE MATERIAL AFTER THE YIELD POINT HAS BEEN REACHED. By A. Nadai and L. H. Donnell. [Paper No. APM-51-16]

This paper covers a study of the distribution of stress in a rotating disk of ductile material (of uniform thickness, with and without a central hole) after the yield point has been passed. Curves are computated showing the growth of the "plastic" region at different speeds, until the whole disk has become plastic. General methods are developed, and applied to examples for finding the complete distribution of stresses and strains in such disks.

While the conditions assumed are seldom exactly realized, the results should throw light on many practical problems as well as form a starting point for a more complete investigation of more complex problems of plastic flow in ductile materials.

STRESSES IN HEAVY, CLOSELY COILED HELICAL SPRINGS. By A. M. Wahl. [Paper No. APM-51-17]

In this paper more exact formulas are derived for computing stress in heavy, closely coiled helical springs of the type used frequently in railway work. These formulas indicate that the maximum stress in such springs may, in many practical cases, be from 40 to 60 per cent greater than the stress computed by the use of ordinary helical-spring formulas. The new formulas are verified by strain measurements, using special extensometers on semi-coils of actual springs loaded so as to simulate the axial loading of a complete spring, and on complete springs loaded in compression. The work indicates that the frequent failures of this type of spring in service may, at least in part, be due to the existence of higher stresses than has been thought possible on the basis of ordinary spring formulas.

GRAPHICAL METHODS FOR LEAST-SQUARE PROBLEMS. By Everett O. Waters. [Paper No. APM-51-18]

Engineering test data are commonly presented in the form of curves. Simultaneous observations are made of two varying quantities; these observations are plotted as points on a plane chart, which affords an x-value and a y-value for each point.

The best curve that can be drawn through these points is that one which reduces the standard error to a minimum, the standard error being defined as the root-mean-square of the errors of all the plotted points.

Unfortunately, the least-square method has, in the minds of most engineers, one great drawback: the involved computations required. The slide rule cannot be used efficiently, because of the mixture of multiplication and addition; furthermore, it is not accurate enough. A simple and accurate device for applying the least-square method without calculation should therefore meet with ready acceptance, and such a one is outlined in the paper. The process is essentially a graphical one, using a planimeter to perform additions and multiplications simultaneously.

FLOW CHARACTERISTICS OF SUBMERGED JETS. By M. J. Zucrow. [Paper No. APM-51-19]

In this paper, which deals with submerged square-edged and chamfered short tubes or jets, the author shows by dimensional analysis and corroboratory experiment that the coefficient of discharge for geometrically similar jets is a function of the rate of discharge, the fluidity of the liquid, and the jet diameter. The effect of changing the angle of chamfer was studied, as well as the influence of the variations in the length-diameter ratio on the discharge characteristic.

HYDRAULIC PAPERS

FLOW IN PIPES. By Michael D. Aisenstein. [Paper No. HYD-51-7]

In this paper the author presents general formulas for the frictional resistance in straight circular pipes based on the experiments of different authorities, and shows their application to the solution of different problems in connection with divided flow and accelerated streamline flow. Illustrative examples are included.

EXPERIMENTAL STUDY OF LOSS OF HEAD IN A CLOSED PIPE CARRYING CLAY SLURRY. By Charles Hanocq. [Paper No. HYD-51-8]

Taking as a basis for his calculations the formulas presented in a previous paper by an American investigator on the loss of head in a closed pipe carrying clear fluids, the author, a Belgian engineer, seeks to apply them to a fluid carrying a heavy proportion of solid materials. The author takes the conclusions in the original paper, which, he

states, seem at first sight somewhat contradictory, and shows that no anomalies exist, and further brings out some precise deductions on the loss of head in a pipe carrying muddy water.

Permissible Suction Head of High-Speed Propeller Turbines. By Arnold Pfau. [Paper No. HYD-51-9]

The paper discusses the general phenomena of pitting and cites the underlying causes. It explains the necessity for special caution in the selection of the setting of a high-speed propeller turbine. To fully realize these causes a new explanation is given of the flow conditions in a high-speed propeller, and it shows that these conditions add an item to the suction head which does not enter into the problem with reaction or action turbines. Particularly this paper emphasizes the wide variation in the characteristics of turbine runners that are termed the "propeller type," and directs attention to the difficulty that may be encountered from generalization based on the use of a single mathematical equation or expression.

Losses of Pressure Head Due to Sudden Enlargement of a Flow Cross-Section. By H. C. Schutt. [Paper No. HYD-51-10]

The exactness of the Borda-Carnot equation for the losses of energy in a liquid medium passing a discontinued cross-section—that is, a sudden enlargement—is discussed, the same formula is derived, based on one of the main principles in dynamics, and a report is given of experiments proving the validity of this formula.

MACHINE-SHOP PRACTICE PAPERS

Cooling and Lubrication of Cutting Tools. [Paper No. MSP-51-8]

This report begins with a review of the many unsettled questions of cutting-fluid performance which have led to the formulation of a general program for research on that subject by the Society in co-operation with the Bureau of Standards and other organizations. Then follows a brief survey of current practice in the selection of cutting fluids for the respective operations and for the various materials to be cut, based upon information received from a number of the leading metal-cutting plants in the United States. Afterward there is given a brief outline of recent experimental work which will be continued as rapidly as financial support is obtained. The report is concluded by appendixes containing (1) a bibliography of cutting-fluids literature; and (2) a chart for tabulating current shop practice in the use of cutting fluids.

The experimental program recommended by the Sub-Committee aims to determine quantitative relations connecting the cutting performance of the fluid in any given process such as finish-turning of steel, with the numerous variables on which it may depend, including not only such factors as speed and depth of cut, but also the physical properties of the fluid, such as its specific heat and its oiliness.

Large Spiral Bevel and Hypoid Gears. By Allan H. Candee. [Paper No. MSP-51-9]

The paper deals with recent developments in the manufacture of large bevel and hypoid gears, the principal subjects being:

1 Large bevel gears of greatly improved running qualities due (*a*) to generating instead of planing the teeth, and (*b*) to the use of spiral teeth instead of straight teeth;

2 A new type of large bevel-gear generating machine designed at the Gleason Works, with a description of the unique combination of mechanical movements used to produce spiral teeth; and

3 The accurate generation of large hypoid gears in which the axis of the pinion is offset from the axis of the gear, thus making it possible for the two shafts to continue past each other.

Widia, Its Development and Shop Applications. By Roger D. Prosser. [Paper No. MSP-51-10]

The history of the development of tungsten-carbide alloys is told, and the part that the Krupp Works has had in it is detailed. Instances are given where the use of Widia cutting tools has speeded up production, in one case the cutting speed having been increased from 190 ft. per min. to 592 ft. The regrinding of Widia tools is stated to be required less frequently than with high-speed tool steel, a case being given where the previous tool was dressed up after 25 parts had been produced, and when Widia tools were used there was a production of 100 parts before regrinding. Its use in machining soft but abrasive materials is compared with the use of the diamond.

Principles of Jig and Fixture Practice. By Joseph W. Roe. [Paper No. MSP-51-11]

The competitive technical advantage of one manufacturing plant over another will usually lie more in the better quality of its small tools, jigs, and fixtures than in differences between the types of machine tools in the respective plants.

Due to the multiplicity and variety of articles manufactured, there is a great diversity of fixtures and holding devices. But through all of them there run certain principles which have been developed gradually and come to be recognized as good practice. Many of these principles can be brought together, and it is the purpose of this paper to do this.

The first and most important element applying to all forms of work holders is the economic one and centers on answering one or more of the following questions:

1 How many pieces must be run to pay for a fixture of given estimated cost which will show a given estimated saving in direct-labor cost per piece?

2 How much may a fixture cost which will show a given estimated unit saving in direct-labor cost on a given number of pieces?

3 How long will it take a proposed fixture, under given conditions, to pay for itself, carrying its fixed charges while so doing?

4 What will be the profit earned by a fixture, of a given cost, for an estimated unit saving in direct-labor cost and given output?

Formulas to solve these questions are developed by the author and their use is shown by illustrative examples.

After this nine conditions under which a jig or fixture should operate are set forth, following which the author outlines certain principles relating to details of design, such as feeds, locating, clamping, and jig legs, bushings, and latches, etc.

An extensive bibliography is given in an appendix.

Worm Gears—A Study and Review of Existing Data. Progress Report No. 2 of the A.S.M.E. Special Research Committee on Worm Gears. [Paper No. MSP-51-12]

This report presents test data on five single- and multiple-thread hardened steel worms running in bronze worm gears which were obtained from actual installations and submitted to the committee. These tests the report compares, using as bases therefor the pitting of tooth surfaces, abrasion and rapid wear of teeth surfaces, and excessive temperature of drive.

Thread Forms of Milled Worms. Progress Report No. 3 of the A.S.M.E. Special Research Committee on Worm Gears. [Paper No. MSP-51-13]

This paper is a continuation of the material on helicoidal sections given in a paper on "Worm-Wheel Contact" presented by Earle Buckingham before the Society in December, 1926. It covers the equations necessary to determine the thread form of milled and ground threads in various sections and also the sections of a helicoid formed by a straight-sided lathe tool, set toward the helix angle of a thread. This last helicoid is a convolute helicoid with the inclination of its generatrix in the opposite direction to that of the helix.

As an example, the worm used in the drive AW-3 in Progress Report No. 2 of the A.S.M.E. Special Research Committee on Worm Gears has been analyzed and the coordinates of the thread form in an axial section have been determined when the thread is produced by a lathe tool, a 4-in.-diameter thread milling cutter, a 12-in.-diameter grinding wheel, and by the flat side of a grinding wheel which would produce an involute helicoid.

This analysis shows that the form in the axial section of a thread produced by a lathe tool, tipped toward the helix angle, will be concave. That produced by a milling cutter may be concave, convex, or a form of double curvature, depending upon the diameter of the cutter, angle of thread, diameter, and lead of screw, and depth of thread.

The curvature increases with a reduction in thread angle and an increase in helix angle. The milled forms become more convex with an increase in the diameter of the cutter or grinding wheel.

This paper's aim is to introduce more mathematics in the machine shop to the end that we may know more definitely the conditions with which we are contending.

Worm Gears—A Study of Service Data. Progress Report No. 4 of A.S.M.E. Special Research Committee on Worm Gears. [Paper No. MSP-51-14]

Using an equation which represents the fatigue load factor, the service data of twelve worm drives were studied by the committee. No definite conclusions were arrived at, but the results obtained may indicate to some degree the influence of worm design on the wear characteristics.

PETROLEUM PAPERS

Progress in the Petroleum Industry. Contributed by the Petroleum Division. Executive Committee: Walter Samans *Chairman*, P. L. Guarin, *Secretary*, T. H. Kerr, H. R. Pierce, C. F. Braun, and W. G. Heltzel. [Paper No. PET-51-1]

This report deals with the principal mechanical engineering developments of the industry, discussing in order production; standardization of production equipment; natural gasoline; transportation; refining; and corrosion.

The Occurrence and Elimination of Surge or Oscillating Pressures in Discharge Lines From Reciprocating Pumps. By H. Diederichs and W. D. Pomeroy. [Paper No. PET-51-2]

This paper deals first with the occurrence of surge or oscillating pressures in the field, in connection with the pumping of oil, resulting in some cases in serious damage. It next reports upon the experiments carried out at Seneca Falls in order to study the phenomenon while all the conditions of operation are under definite control. This is followed by a study of the theory which underlies the occurrence, and definite recommendations are given to eliminate it. It is pointed out that the means at hand for doing this are twofold: (*a*) The establishment of a proper relation between pump speed and length of discharge line, and (*b*) the use of air chambers. A diagram is given which shows the relation between length of line and the critical speed of duplex and triplex pumps, and the paper concludes with a discussion of air-chamber design and operation.

Centrifugal Pumps in the Oil Industry. By W. R. Layne. [Paper No. PET-51-3]

During the past ten years the centrifugal pump has met with increasing favor in the oil industry and found its greatest usefulness in the pipe-line and refining divisions. In the present paper the author briefly discusses the characteristics of such pumps and the factors that affect their performance, following which he deals at length with their application in various branches of the industry and compares the cost of pumping oil by centrifugal pumps and by oil-engine plunger pumps.

Economics of Electric Pipe-Line Pumping. By J. B. Thomas. [Paper No. PET-51-4]

This paper reviews the "state of the art" in both the oil-pipe-line and the electric-power-supply industries as affected by the use of electric power for pipe-line pumping. It indicates the general construction and operating costs of pipe-line pumping stations and certain economic factors affecting the cost of pumping oil. A method of analysis including these factors is outlined, and a detailed solution of a typical problem given.

The author's viewpoint is primarily that of an engineer trained in the electric-power industry, and therefore this discussion covers the analysis of the comparative overall economic results to be obtained by using generally accepted methods and practice, rather than the details of design and operation of pipe lines or stations.

MANAGEMENT PAPERS

Progress in Industrial Management. Contributed by the Management Division. Executive Committee: W. L. Conrad, *Chairman*, Park T. Sowden, *Vice-Chairman*, Geo. E. Hagemann, *Secretary*, Robt. E. Newcomb, W. R. Clark, and Wm. B. Ferguson. [Paper No. MAN-51-1]

This report reviews the advances made in management during the year under the following headings: standardization of output and equipment; elimination of waste and its relation to cost; replacement of obsolete equipment in industry; distribution and marketing of product; purchase of equipment; simplified practice; training of salesmen and their relation to costs of marketing; economical management in industry; budgetary control; time study, etc.

A Basis for Evaluating Manufacturing Operation. By L. P. Alford and J. E. Hannum. [Paper No. MAN-51-2]

In this paper the authors propose the number of man-hours worked as a basis for evaluating such factors in manufacturing operations as productivity, labor permanence, fixed-capital investment, primary power, industrial accidents, costs, profits, and selling prices. They also consider and interpret these factors as they are revealed by the analysis, on the above-mentioned basis, of records of over 13,000 plants, employing nearly 2,000,000 workers in 100 industries.

Management Engineering in the Smaller Industrial Plants. By J. E. Dykstra. [Paper No. MAN-51-3]

The author discusses in this connection production control, proper routing, proper costing, grouping and classification of equipment, and possibilities of modern equipment and importance of the operating personnel.

The Executive Function in Industry. By Robert T. Kent. [Paper No. MAN-51-4]

This paper is a plea for the more general adoption of budget control in manufacturing industry. It outlines the method of making up a budget, and the relations of the sales, production, purchasing, and financial functions, and their coordination through the budget. It also shows how the budget may be used to expose inefficiencies in the operation of an industry.

Scientific Management and Its Effect Upon Manufacturing. By Robert M. Meyer. [Paper No. MAN-51-5]

This paper sets forth some specific results of scientific management in a small plant manufacturing machinery for the printing and bookbinding trades, consisting principally of feeders, folders, inserters, and stitchers. To meet the needs of specific installations it is necessary, in nearly all cases, to make changes in the products from that furnished previously. This makes it necessary for each order to pass through the engineering department and imposes a severe handicap on the application of scientific management. However, in spite of this, during the period of 1921 to 1927, (1) a constantly improved product was manufactured at a much lower unit cost; (2) the average wage was increased approximately 30 per cent, and (3) production was increased approximately 50 per cent with practically the same number of employees. How this was done is outlined by the author.

Standard Costs as Applied to Craftsmen's Industries. By William M. Passano. [Paper No. MAN-51-6]

The author sets forth the advantages of standard unit costs and briefly outlines the procedure to be employed in obtaining them.

Outstanding Economic and Technical Factors Involved in the Engineering of New Manufacturing Equipment. By J. R. Shea. [Paper No. MAN-51-7]

The importance of the problem of selecting or developing new and improved manufacturing equipment which is best suited for the economical production of a finished article of the desired quality is pointed out, and then the basic principles underlying the solution of this problem are discussed. The subject is developed under the three main headings of (1) the economic analysis, (2) the technical analysis, and (3) practical applications. The economic analysis is essentially a summary of the various elements of cost involved in a proposed manufacturing plan, and the final choice of the equipment is based on this analysis. The author presents an economic analysis which is a composite of several recent developments of his company, stating that this analysis is the result of an intensive study of the technical phase of the question. He then proceeds to discuss the technical analysis, which comprises a study of the design of the product in all its stages, including the trend in its development, and of the question of methods of processing, these being the more important factors that influence the choice of proper equipment. In the author's opinion, equipment should be selected on the basis of the facts developed by the analyses described and with the ultimate plan of the entire plant in mind, to the end that each machine may function as a part of a single economic unit. Several important items are mentioned relating to the selection of standard equipment, and a description is given of several special machines developed to meet the manufacturing needs of the Western Electric Company.

Symposium on Illumination. [Paper No. MAN-51-8]

The first paper of this symposium by H. H. Higbie and W. C. Randall, outlines a method by which the amount and distribution of daylight illumination that should be produced by any specific window arrangement in the interior of a building may be predicted. The method is based upon rigorous theoretical analysis and has been checked repeatedly by field tests upon full-size buildings as well as by laboratory tests upon models of buildings. Some results of the application of the method to analysis of the lighting effect of changes in the fenestration of typical buildings are discussed. A bibliography and a brief digest of the most significant literature known to the authors include important data on the effects of window glass, shades and blinds, mullions and columns, light-reflecting surfaces both within and without the building, sawtooth, monitor, and other types of roof in single-story buildings, and light courts in multi-story buildings.

Ward Harrison in the second paper, points out that since daylight provides adequate illumination for only about one-half of the working area in a modern multi-story factory building, artificial illumination is essential for effective use of the entire space for productive purposes. The procedure for the correct design of such systems is outlined in the paper.

The third and last paper by C. C. Munroe and H. A. Cook, considers light as an important factor in the successful operation of any industrial plant. Inadequate lighting, i.e., lighting of a low intensity with glare present and the illumination improperly distributed throughout the interior, will hinder the various industrial processes, while adequate lighting, i.e., sufficient intensity, glare eliminated, and a satisfactory distribution of light, will assist in the operation of industrial plants.

Adequate lighting will increase production, the average increase being 15 per cent at a 2 per cent cost of the payroll; it will decrease industrial accidents, this reduction producing a saving in plant operation costs; it will reduce labor turnover and spoilage, again assisting in the production of materials at a low cost; and it will assist in the maintenance of the health of the employees, which tends to produce a greater organization efficiency.

These factors, with their combined influences, make it highly desirable that the lighting of a plant receive consideration similar to that of the machinery to be installed, because it can question that the efficient operation of an industrial plant is influenced to a certain extent by the character of the illumination used.

PRINTING INDUSTRIES PAPERS

Progress in the Printing Industries. [Paper No. PI-51-1]

This report enumerates the new things in printing machinery and appliances that have been developed in the year 1928, with a description of the latest methods in pulp and paper making. Machines that have effected increases in speed and in production are also discussed.

Symposium on Paper and Ink as the Raw Products of Manufacture and the Conditions That Affect Them. [Paper No. PI-51-2]

Paper and ink are treated just as any raw material for factory production, and the conditions that affect them in the pressroom are described, such as offset, humidity, static electricity, and temperature; and methods of modifying or controlling these factors are given.

The Reorganization and Reconstruction of the Newspaper Printing Press. By Henry A. Wise Wood. [Paper No. PI-51-3a]

The development of one type of newspaper press is described, with all the experimentation and modification that led to the use of steel and roller bearings. The surface of newsprint in customary use is shown in magnified form, with the impression made by the inked printing plate.

Evolution of Today's Newspaper Press. By John R. Tomlin. [Paper No. PI-51-3b]

The beginnings of many devices now common in printing presses are told, together with the discoveries and the patents that have been effective in producing the modern high-speed printing press used in the newspaper plants of today.

The Modern High-Speed Unit Newspaper Press. By Carl E. Drange. [Paper No. PI-51-3c]

The engineering skill that has entered into the manufacture of the latest types of newspaper printing machine is detailed, showing that a daily paper must rely in many cases on one dependable machine for uninterrupted production, a thing not customary in other industries.

Electric Drive for High-Speed Newspaper Presses. By W. L. Wright. [Paper No. PI-51-4]

The characteristics of alternating- and of direct-current drive for the modern high-speed newspaper printing press are outlined, together with the mechanism for control of the operation of the fast-running machine as effected by electric devices.

The Manufacture of Newsprint for High-Speed Printing Presses. By George D. Bearce. [Paper No. PI-51-5a]

The manufacturing engineer of one of the great newsprint manufacturing companies describes in detail the manufacturing methods to produce a dependable roll of paper for the rotary printing press, and lists the many safeguards that the mill exercises.

Fundamentals of Good Quality of Printing in Newspaper Plants. By H. E. Vehslage. [Paper No. PI-51-5b]

A printing-press engineering representative makes up a remarkable chart of the thousand things that enter into the successful production of good-quality printing in modern newspaper plants, and points out the responsibility for faults and for troubles.

NOTE: Those who have not registered in the A.S.M.E. Aeronautic, Applied Mechanics, Hydraulic, Machine-Shop Practice, Petroleum, Management, and Printing Industries Divisions whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.

To the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y. Date............................

Please send copies of papers checked below:

Aeronautics [AER-51-6] [AER-51-7] [AER-51-8] [AER-51-9] [AER-51-10] [AER-51-11] [AER-51-12] [AER-51-13] [AER-51-14] [AER-51-15] [AER-51-16] [AER-51-17] [AER-51-18] [AER-51-19]

Applied Mechanics [APM-51-1] [APM-51-2] [APM-51-3] [APM-51-4] [APM-51-5] [APM-51-6] [APM-51-7] [APM-51-8] [APM-51-9] [APM-51-10] [APM-51-11] [APM-51-12] [APM-51-13] [APM-51-14] [APM-51-15] [APM-51-16] [APM-51-17] [APM-51-18] [APM-51-19]

Hyraulics [HYD-51-7] [HYD-51-8] [HYD-51-9] [HYD-51-10]

Machine-Shop Practice [MSP-51-8] [MSP-51-9] [MSP-51-10] [MSP-51-11] [MSP-51-12] [MSP-51-13] [MSP-51-14]

Petroleum [PET-51-1] [PET-51-2] [PET-51-3] [PET-51-4]

Management [MAN-51-1] [MAN-51-2] [MAN-51-3] [MAN-51-4] [MAN-51-5] [MAN-51-6] [MAN-51-7] [MAN-51-8]

Printing Industries [PI-51-1] [PI-51-2] [PI-51-3a, 3b, 3c] [PI-51-4] [PI-51-5a, 5b]

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A.S.M.E. Annual Meeting Program

New York, December 2 to 6, 1929

(The Conference of the Local Sections' Delegates will begin Sunday, December 1 at 2:00 p.m.)

MONDAY, DECEMBER 2

9:30 a.m. Council Meeting
Conference of Local Sections' Delegates
Simultaneous Sessions on—

Hydraulic Power

Power—Steam or Hydro or Both, WM. W. TEFFT
Increased Kilowatt Output of Adjustable-Blade Propeller Turbines, C. R. MARTIN
Mechanical Vibrations in Penstocks of Hydraulic-Turbine Installations, J. P. DENHARTOG *(by title)*

Mechanical Springs

The Radially Tapered Disk Spring, W. A. BRECHT and A. M. WAHL
Present Status of the Mechanical-Spring Art, J. K. WOOD
Elastic and Inelastic Behavior in Spring Materials, M. F. SAYRE. Fifth Progress Report of Special Research Committee on Mechanical Springs

Applied Mechanics (I)

Factor of Safety and Working Stress, C. RICHARD SODERBERG
The Mechanics of the Plastic State of Metals, A. NADAI

1:00 p.m. Luncheon of Council and Local Sections' Delegates
2:00 p.m. Simultaneous Sessions on—

Machine-Shop Practice

Quantity Control and Production Gages, EARLE BUCKINGHAM

Hydraulic Turbines

Changing Requirements in Regulation of Hydroelectric Units, F. NAGLER
Mechanics of Hydraulic-Turbine Pressure Regulation, A. PFAU
Progress Report of Hydraulic Division

Applied Mechanics (II)

Torsional Vibration Dampers, J. P. DENHARTOG and J. ORMONDROYD
Power Application to Oscillating Axles, A. MADLÉ

Power Test Codes Public Hearing

Test Code for Liquid Fuels

2:15 p.m. Conference of Local Sections' Delegates
2:30 p.m. Council Meeting
8:00 p.m. Business Meeting
8:30 p.m. Open House
Ladies Annual Get-Together

TUESDAY, DECEMBER 3

9:30 a.m. Conference of Local Sections' Delegates
Simultaneous Sessions on—

Fuels

Soot Particles in New York City Air, E. E. FREE
Progress Report of Fuels Division

TUESDAY, DECEMBER 3—Continued

9:30 a.m.

Materials Handling (I)

The Application of Aerial Tramways to Long and Short Hauls, M. P. MORRISON
Progress Report of Materials Handling Division

Applied Mechanics (III)

Natural Frequency of Gears, R. E. PETERSON
The State of Stress in Full Heads of Pressure Vessels, W. M. COATES

2:00 p.m. Simultaneous Sessions on—

Economics of Delivery Vehicles

Economic Aspects of Gasoline-Operated Commercial Vehicles, R. E. PLIMPTON
The Economics of the Electric Truck in Delivery Service, CHARLES R. SKINNER, JR.

Cutting Metals

(Jointly with Machine Shop Practice Division)

Turning With Shallow Cuts at High Speeds, H. J. FRENCH and T. G. DIGGES
Power Required to Drill Cast Iron and Steel, O. W. BOSTON and C. J. OXFORD
A Test Code for High-Speed Steel for Turning Tools, L. H. KENNEY. Report of Sub-Committee D on Properties of Materials of the Special Research Committee on Cutting of Metals
Present Practice in the Use of Cutting Fluids, S. A. MCKEE. Progress Report No. 2 of Sub-Committee on Cutting Fluids

2:15 p.m. Conference of Local Sections' Delegates
8:30 p.m. Report of Nominating Committee
Introduction of President-Elect
Henry Robinson Towne Lecture by DR. ALEJANDRO E. BUNGE of Buenos Aires, Argentina, S. A.
Engineers in American Life, L. W. WALLACE and J. E. HANNUM
Reception and Dance

WEDNESDAY, DECEMBER 4

9:30 a.m. Simultaneous Sessions on—

Industrial Power

The Pioneer 1800-Lb. Pressure Power Plant in America, W. E. S. DYER

Department Management

Management of Service Department: Budgeting and Wage Incentives Applied to a Large Organization, WILLIAM B. FERGUSON and TOM H. BLAIR

Lubrication

(Jointly with Machine Shop Practice Division)

Performance of Oil-Ring Bearings, GEORGE B. KARELITZ
The Service Characteristics of Diesel-Engine Lubricating Oil, A. E. FLOWERS and M. A. DIETRICH

(Continued on the following page.)

WEDNESDAY, DECEMBER 4—Continued

2:00 p.m. Simultaneous Sessions on—

Education and Training for the Industries of Non-College Type

Report on the Study of Non-College Technical Education, W. E. Wickenden
Suggestions for Encouraging Education and Training for Industry, H. S. Falk

Student Branches

Steam-Tables Research

Power Test Codes Public Hearing

Test Code for Complete Steam-Electric Power Plants

6:30 p.m. Annual Dinner, Hotel Astor

THURSDAY, DECEMBER 5

9:30 a.m. Simultaneous Sessions on—

Production Management

Advantages Derived from the Simplification of the Fundamental Formulas for Economic Production Quantities, Fairfield E. Raymond
Twelve Years' Experience With Economic Production Quantities, C. H. Best
The Use of Economic Manufacturing Quantities, Robert W. Kent

Central-Station Power

The Effect of Large Boilers Operated at High Capacities on the Operating Characteristics and Investment Costs of Boiler Plants, F. S. Clark
Performance of Modern Steam-Generating Units, C. F. Hirshfeld and G. U. Moran

Railroad (I)

High-Pressure Locomotives, A. F. Stuebing
Locomotive Auxiliary Power Mediums, George W. Armstrong
Progress Report of Railroad Division

Oil and Gas Power

Progress Report of Oil and Gas Power Division
Engineering and the Oil Industry, Geo. L. Reid
Progress Report of Special Research Committee on Diesel Fuel Oil Specifications

2:00 p.m. Simultaneous Sessions on—

Railroad (II)

Heat Transfer in the Locomotive Superheater, Lawford H. Fry
Metallurgy in the Railroad Field, Charles McKnight

THURSDAY, DECEMBER 5—Continued

2:00 p.m.

General

Working Stresses for Steel at High Temperatures, D. S. Jacobus
A Study of Tin-Base Bearing Metals, G. B. Karelitz and O. W. Ellis

Application and Dimensional Analysis in Fluid Flow

Quantity-Rate Fluid Meters, Ed. S. Smith, Jr.
Similarity: Limitations in Its Application to Fluid Flow, J. M. Spitzglass
The Flow of Fluids Through Orifices in 6-In. Pipe, S. R. Beitler
Reports of the Sub-Committees of the Fluid Meter Committee

3:00 p.m. Ladies' Annual Tea

Evening College Reunions

FRIDAY, DECEMBER 6

9:30 a.m. Council Meeting

Simultaneous Sessions on—

Boiler Feedwater Studies

Recent Instances of Embrittlement in Steam Boilers, Frederick G. Straub

Aeronautics

Recent Developments in Aircraft Engine, John H. Geisse
Factors in the Design of Commercial Airplanes, Charles T. Porter

Textiles

General Design and Operating Features of Range or In-Train Drives for Finishing Plants, Wendell S. Brown
Progress Report of Textile Division

2:00 p.m. Simultaneous Sessions on—

Rail-Motor Cars

(Railroad and Oil and Gas Power Divisions Jointly)

The Design and Application of Rail-Motor Cars, C. O. Guernsey

Refrigeration

(Jointly with A.S.R.E.)

Thermodynamics of Air Cooling, Barton H. Coffey (contributed by A.S.R.E.)
Engineering Computations for Air and Gases, Sanford A. Moss and C. W. Smith

Furniture Production

From the Master Cabinetmakers to Woodworking Machinery, J. D. and Margaret S. Wallace
Modern Method of Manufacturing Classical Furniture, Harry Kimp
Progress Report of Wood Industries Division

Synopses of A.S.M.E. Annual Meeting Papers

THESE papers, abstracts of which are being published on this and the following pages, are being printed in pamphlet form for the 1929 A.S.M.E. Annual Meeting. They may be secured by filling out the blank on page 889 of this issue. Order by number, using the list given on page 890.

AERONAUTICS

Recent Developments in Aircraft Engines. By John H. Geisse, Vice-President of Engineering, Comet Engine Corporation, Madison, Wis.

Improvements in engine design for airplanes during the past year have been gradual. Production facilities now exceed the demand and developments should come more rapidly. There has been a trend during the past year toward the "in-line" or air-cooled types of engines. However, the radial type still possesses a number of advantages. Manifolding in radial engines is quite a problem due to the impossibility of getting symmetry except in nine-cylinder types where three three-way manifolds may be used.

Cylinder construction with a steel sleeve having machined cooling fins and a cast-aluminum head is accepted quite universally, and there is a trend toward the use of heat-treated alloys for the crank case. Many interesting developments in the Diesel types of airplane engines can be expected.

Factors in the Design of Commercial Airplanes. By Charles Talbot Porter, Chief Engineer, Keystone Aircraft Corporation, Bristol, Pa.

A steady and profitable market may be expected for existing equipment in remote and inaccessible places, where other forms of transportation are not available, but the real problem is to make the air transport compete successfully with the extra-fare trains. The real commodity that is being sold is transportation, and the factors involved are speed, comfort, and cost, assuming of course that safety and reliability have already been demonstrated. The combination of these three factors must equal that of the fast train. The cost of air travel is of necessity high, therefore the speed-comfort combination must exceed that of the railroads. In general, the comfort of the train at least equals that of the airplane, so the latter must be sold on the speed factor alone, without sacrifice of a certain minimum requirement for comfort, and at a cost that is justified by the increase in speed.

The writer advocates the development of a 30- to 40-passenger airplane that will equal present speed requirements with a reduction of power to 50–60 hp. per passenger. To obtain this result he advocates abandoning direct-drive air-cooled radial engines and replacing them by geared engines, air-cooled or liquid-cooled, placed preferably inside the wing, with a remote drive to the propellers. The airplane itself should approach the flying wing, the wing loading should be high, and the landing gear should be retractable. Due to increase in landing speed the brakes should be much larger, should be operated by mechanical power, and should be capable of utilizing the full friction between the wheels and the ground. The material from which the airplane is made will depend largely on a depreciation factor which is not yet clearly defined and cannot be set up until large airplanes have been in operation for a longer period of time.

APPLIED MECHANICS

The Mechanics of the Plastic State of Metals. By A. Nadai, Research Department, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Formerly Professor of Applied Mechanics, University of Goettingen, Germany.

A study of the mechanical conditions under which plastic flow in the metals occurs. Discussion of rules relative to the stresses and the deformation when the stresses reach the limit of plasticity. Some cases of plastic flow with rotation symmetry around an axis in cylinders are considered. As examples are treated the case of a bar in combined tension and torsion and of a hollow cylinder subjected to a high internal pressure and axial forces. The cases of pure bending of a bar with a rectangular cross-section and of pure torsion of a bar with a circular cross-section are discussed, assuming a general law of deformation. Application of this theory to the hollow cylinder subjected to internal pressure. The results should throw light on the problem of residual stresses. Discussion of methods to find the residual stresses after severe plastic deformation.

The Radially Tapered Disk Spring. By W. A. Brecht and A. M. Wahl, respectively of Railway Motor Eng. Dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa., and Research Lab., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

In this paper disk springs, both flat and dished, having radially tapered cross-sections are considered. The advantages of such springs are discussed. Equations are developed by approximate and more exact methods for calculating the strength flexibility of such springs. The theoretical work is checked up by numerous tests, including both strain and deflection measurements. It is concluded that springs of this type may be of advantage in certain applications.

The State of Stress in Full Heads of Pressure Vessels. By W. M. Coates, Instructor in Engineering Mathematics, University of Michigan, Ann Arbor, Mich.

After a brief survey of the significant experiments upon which a comparison with the theory developed is to be based and a statement of the problem, the author derives expressions for stresses and displacements at any point of a thin-walled pressure vessel.

Assuming that the shell offers no resistance to bending, an analysis is made considering it as a membrane. A study of the resulting equations indicates that in the neighborhood of the junction of head and cylinder, bending couples result, so that the plates may not be considered as membranes, at least in this locality.

This leads to a consideration of the local effects of the reactions set up at the junction, the head and cylinder being considered as surfaces capable of carrying bending stresses with loads which are uniformly distributed edge shearing forces and bending couples. The resultant effect at any point is obtained by superposition. An illustrative example is given.

Mechanical Vibrations in Penstocks of Hydraulic-Turbine Installations. By J. P. DenHartog, Research Lab., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

The subject of penstock vibration has come up repeatedly and was intensively investigated by R. Wilkins in 1923. In the present paper an explanation of this effect is given, with a simple rule regarding the number of buckets and guide vanes, by which it is possible to keep this vibration within satisfactory limits. The theory was checked up on eight different installations, and showed good agreement with them.

Power Application to Oscillating Axles. By Alain Madlé, Relay Motors Corporation, Lima, Ohio.

This paper gives definite effects that result from use of a differential drive to an oscillating axle.

1 By means of the differential drive, torque can be applied to the wheel without turning it. This gives the effect of a second clutch in the power line in which no energy is destroyed.

2 The oscillating axle, by providing an elastic connection between power line and rear wheel, cushions torsional impacts.

3 Whenever there are changes in the running conditions of the vehicle, fluctuations of energy between rear-wheel assembly and vehicle body take place, and that the reaction forces of these fluctuations provide an increased pressure against the ground.

4 By virtue of the fluctuation between rear-wheel assembly and vehicle body, an additional accelerating force is applied to the driving wheels in starting and accelerating.

5 Due to the transformation of part of the vehicle momentum into potential energy, an additional retarding force is provided when the brakes are applied.

Torsional-Vibration Dampers. By J. P. DenHartog and J. Ormondroyd, respectively of the Research and Railway Motor Engineering Departments, Westinghouse Electric and Manufacturing Co., E. Pittsburgh, Pa.

A theory is given of the action of friction dampers on systems in torsional resonance, with special application to gas and Diesel-engine installations. Model tests, carried out to check this theory, are described. The effect of introducing springs in the Lanchester damper is discussed.

Engineering Computations for Air and Gases. By S. A. Moss and C. W. Smith, Thomson Research Laboratory, General Electric Co., Lynn, Mass.

In this paper the authors give methods of making the usual engineering computations for adiabatic compression, expansion, flow through measuring nozzle, and similar work concerned with thermodynamic properties of air and gases. The methods are devised to provide the greatest accuracy possible with engineering methods.

Natural Frequency of Gears. By R. E. Peterson, Research Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

The natural frequency of machine parts as related to the noise problem in machine operation is discussed in a general manner. Vibration phenomena in disks and rings are described in detail, following which the author discusses the manner in which a gear vibrates at its natural frequency. An empirical formula is given for the natural frequency of a gear in terms of its dimensions and material.

Elastic and Inelastic Behavior in Spring Materials. By M. F. Sayre, Assistant Professor of Applied Mechanics, Union College, Schenectady, N. Y.

Since the last progress report was published, work on the behavior of spring metals in direct stress has been done which has clarified several points which were then uncertain, and which has opened several new points regarding elastic behavior. In particular, the experimental results suggest the following conclusions:

1 Occasional overloads in tension up to the elastic limit of spring steel or phosphor bronze do not affect its elastic properties.

2 For these purposes, the elastic limit must not be taken as synonymous with the proportional limit. In last year's report, both an upper and a lower proportional limit were given, with two moduli of elasticity for the different portions of the stress-strain curve.

3 For stress ranges in tension within the elastic limit of the material, the amount of hysteresis, the "backlash" in elongation between increasing and decreasing loads, increases with the load range, varying with load as some power between the square and cube.

4 The true shape of the hysteresis loop is apparently more or less like a string-bean pod rather than an ellipse. It is eccentrically pointed at each end, and often (depending on the relative height and width of the loop) may have a slight in-curve on the lower side.

Similarity: Limitations in Its Application to Fluid Flow. By J. M. Spitzglass, Vice-President and Consulting Engineer, Republic Flow Meters Co., Chicago, Ill.

A brief résumé of the development of the art for the purpose of bringing about a better understanding of the effects of hydraulic similarity as related to the geometrical similarity of the various devices. Geometrical similarity is of great importance, and devices which are geometrically similar will make the operation more uniform. Geometrical similarity is a matter of construction. Hydraulic similarity is a matter of experiment. Large sizes may or may not show the same results as the smaller ones.

Factor of Safety and Working Stress. By C. Richard Soderberg, Asea, Vesteris, Sweden.

This paper contains a general discussion of the fundamentals on which working stresses in machine parts should be based. The terms "failure" and "factor of safety" are also discussed. Rules for the determination of working stress as established by the East Pittsburgh Works of the Westinghouse Co. are given. It is stated as the author's opinion that the engineering profession is in need of a general code on the subject of working stress. The beginning of such a code has been made in the "Code for Design of Transmission Shafting" approved by the Engineering Standards Committee in 1927. In an appendix, this code is also discussed. It is hoped that this paper may lead to some action on the part of the A.S.M.E. toward the establishment of a general code on the subject.

FUELS AND STEAM POWER

The Flow of Fluids Through Orifices in Six-Inch Pipe. By S. R. Beitler, The Ohio State University, Columbus, Ohio.

Increased use of flow meters for measuring flow of various fluids used in the production of power has created a demand for increased accuracy in the meters. This report covers the work done, under the direction of the Special Research Committee on Fluid Meters, in the calibration of orifices and a nozzle in a 6-in. pipe line, using water and steam as the fluids to be metered. Information as to the orifices used, the method of taking data, the calibration of instruments, and the results obtained are given in the report.

The Pioneer 1800-Pound Pressure Power Plant in America. By W. E. S. Dyer, Designing and Consulting Engineer, Philadelphia, Pa.

This paper gives the details of design and construction of a high-pressure power plant, using reciprocating engines, for the Philip Carey Manufacturing Co., Cincinnati, Ohio.

Soot Particles in New York City Air. By E. E. Free, School of Commerce, Accounts and Finance, New York University, New York, N. Y.

In this paper the author tells of the methods used and the results obtained in a series of counts of soot and dust particles in the air of New York City. The counts were made by an impact dust counter. Two variables affect the results. One is the wind and the second, the degree of clumping or flocculation of the soot particles in the air. The number of soot particles counted showed a high degree of correlation with wind direction. Nothing was discovered to show the causes for clumping of the soot particles.

Working Stresses for Steel at High Temperatures. By D. S. Jacobus, Advisory Engineer, Babcock & Wilcox Co., New York, N. Y.

Certain of the published results for the stress to produce creep at higher temperatures have led to apprehension in the employment of stresses that have been used, and it is the object of the paper to dispel such apprehension for the particular stresses which are discussed.

The results secured in practical experience are used for setting the maximum working stresses up to temperatures of 800 deg. fahr., and for temperatures above 800 deg. fahr. the working stresses are scaled down in proportion to the falling off of the stresses that produce creep. The first curve of creep points published by Mr. French of the Bureau of Standards was used and the working stresses for a given temperature are taken at $^2/_3$ the creep-point stress. The effect on the stress of piercing a boiler shell with holes and of transmitting heat through the shell is discussed, as well as the tendency toward equalization of stress through extension of the most strained fiber. The tendency of the creep to equalize the stresses is also brought out.

The method of extrapolation used by different authorities is discussed and the conclusion reached that more exact results are obtained by using the method employed by Prof. F. H. Norton in his book on the "Creep of Steel at High Temperatures" than by some other methods.

Quantity-Rate Fluid Meters. By Ed. S. Smith, Jr., Hydraulic Engineer, Builders Iron Foundry, Providence, R. I.

The art of metering fluids is becoming of increasing importance since accurate quantity-rate meters are required for modern industrial uses and for the control of continuous processes in the manufacture of enormous quantities of highly uniform products.

In this paper the acoustic-velocity ratio has been developed and

its use simplified by the author until it forms a practical basis for correlating expansion corrections for both the venturi tube and orifice for various fluids. In the past several years a number of investigators have published material which establishes confidence in the soundness of this use of the acoustic-velocity ratio for fluid meters.

RECENT INSTANCES OF EMBRITTLEMENT IN STEAM BOILERS. By Frederick G. Straub, Department of Chemistry, University of Illinois, Urbana, Illinois.

The author discusses briefly the cause of the recent boiler explosion at Crossett, Arkansas, attributing the failure to embrittlement produced as a result of using soda-ash treatment on a water too low in sulphate content. Other instances of cracking of seams in steam boilers are also described. Emphasis is placed upon the regular inspection of leaky seams in steam boilers, particularly when the boiler water does not meet the A.S.M.E. recommendations.

THE EFFECT OF LARGE BOILERS OPERATED AT HIGH CAPACITIES ON THE OPERATING CHARACTERISTICS AND INVESTMENT COSTS OF BOILER PLANT. By Frank S. Clark, Consulting Engineer, Stone & Webster Engineering Corporation, Boston, Mass.

The paper treats of the various factors that enter into the design of boiler plants, their effect on investment costs and on operating characteristics. It traces the development of the boiler plant from a number of small units operated at moderate capacities to the present plant of a few large units run at high rates of evaporation. It gives the conditions that limit the sizes and output and shows how, as the demand for larger units increase, these conditions have been overcome. The paper shows the effect of large units in reducing the sizes of buildings to house them, and the number of auxiliary equipment to serve them. It shows the effect of reliability of equipment on increased service factor, with consequent reduced necessity for spare equipment. It states that the governing factors in investment costs for a given condition are the size of the unit and the output obtainable, the former depending on the ability to manufacture and the latter on the fuel that can be burned in the furnace and the ability of the unit to absorb the heat. Further, it discusses the proportioning of heat-absorbing surfaces between boiler, economizer, and air preheater to obtain the most economic result at minimum cost, and also the effect on operation of large units run at high capacity and in turn their effect on labor and maintenance cost. The paper concludes with a table giving an analysis for a given condition of the installation of boiler plant containing different numbers of different sizes of boilers.

HYDRAULICS

INCREASED KILOWATT OUTPUT OF ADJUSTABLE-BLADE PROPELLER TURBINES. By C. R. Martin, Engineer, Hydraulic Department, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

The adjustable-blade propeller-type hydraulic-turbine runner is now recognized as an advance in hydraulic-turbine design. The characteristics of this type of runner are described by the author in this paper, together with experiences to illustrate its advantage. Most of the installations made so far operate with a controlled water supply, or the load conditions are such that the blades can be adjusted at any time.

CHANGING REQUIREMENTS IN REGULATION OF HYDROELECTRIC UNITS. By F. Nagler, Engineer, Hydroelectric Department, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

The development of power from water has successfully passed through the stages of millstone drive, mechanical-mill drive, electric-mill drive, electric-system drive, and of late, tremendous system interconnection. Throughout all but the first stage there has been little or no change in the fundamental means of speed regulation.

This paper deals with the basic requirements of regulation, illustrating especially the inherent speed change of about two cycles necessary between no load and full load to permit of automatic division of load between units operated in parallel, and illustrates the successive changes that are being made to correct the undesirable effects produced by that requirement. This secondary frequency regulation is further analyzed in its prohibitively uneconomical effect on kilowatt-hour production from both run-of-river and storage plants. The necessity for ideal operation of hydro units, that is, operation at but a single point in their gate-opening curve, is illustrated, and conclusions are arrived at as to the ideal operation of units under conditions made possible by extensive system interconnection.

MECHANICS OF HYDRAULIC-TURBINE PRESSURE REGULATION. By Arnold Pfau, Consulting Engineer, Hydraulic Department, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Problems of pressure control or the pressure variations resulting from the action of the governor complicate calculations of hydraulic turbines. This paper describes mechanical means whereby desired field results can be obtained under existing conditions of operation and of pipe-line characteristics. Calculations, formulas, and examples of speed and pressure control take up such points as closing gates, passing through position of static balance of turbine gates, formulas for speed regulation, effect of pressure variations on speed, and calculations of pressure rises in pipe lines.

POWER—STEAM OR HYDRO OR BOTH. By William W. Tefft, Construction Engineer, Jackson, Mich.

Emphasis is placed on the necessity of including all pertinent factors in a comparison of steam with hydro power, drawing attention to the fact that any conclusions based upon a part of these factors will be erroneous, misleading, and valueless. In considering the various factors that go to make up the final conclusion attention is called to the superiority of steam power where need for power is immediate, where the more profitable hydro sites have already been developed, and where the actual load factor is very high. It is also made clear that hydro power is superior in reliability and as reserve capacity and can operate to advantage at a much lower load factor than can steam. It might be said that the paper deals largely with load factor. Curves based upon larger number of developments in each case, indicate that usually for 60 per cent load factor or less the hydro plants are superior, the statement being made that no steam plant can now be built for 25 per cent load factor that will produce current for one cent per kw-hr., but there are many water-power plants, most of them in fact, that can do this.

It is concluded that there is ample proof that a power system combining both steam and hydro plants can generate power cheaper than either kind of prime mover for the same conditions, thus indicating the mutual advantage of one to the other.

IRON AND STEEL

A STUDY OF TIN-BASE BEARING METALS. By G. B. Karelitz and O. W. Ellis, respectively Research Engineer, Westinghouse Electric & Manufacturing Co., E. Pittsburgh, Pa., and Ontario Research Foundation, Toronto, Canada.

This paper is a continuation of that presented by the authors at the Pittsburgh Meeting of the A.S.M.E. in 1928 and deals with the mechanism of wiping of babbitt linings, with certain phenomena observed during the casting of tin-base alloys, and with the effects of cold work on them. It is shown that wiping of babbitts is a result of the upper layer of the lining's reaching the solidus temperature; when the constituent with the lowest melting temperature liquefies, the babbitt becomes "mushy" and is therefore wiped by the journal. The appearance of the castings of various chemical composition is discussed and the variation in hardness and microstructure due to cold work is given.

MACHINE SHOP PRACTICE

POWER REQUIRED TO DRILL CAST IRON AND STEEL. By O. W. Boston and C. J. Oxford, respectively Professor, College of Engineering, University of Michigan, Ann Arbor, Mich., and Chief Engineer, National Twist Drill & Tool Co., Detroit, Mich.

The object of this paper is to present the results of a series of tests in drilling steel and cast iron with sharp standard twist drills ranging in drameter from $^1/_2$ to $1^1/_2$ in. It was felt desirable to obtain data representing the torque, thrust, and net horsepower developed at the point of the drill for some of the modern high-speed-steel twist drills, when cutting a variety of types of steels and cast irons used widely in modern industry.

Quantity Control and Product Gages. By Earle Buckingham, Associate Professor of Engineering Standards and Measurement, Massachusetts Institute of Technology, Cambridge, Mass.

In this paper the author discusses basic principles entering into quantity control and the use of production gages. The development of interchangeable manufacturing has many advantages and should result in economies. Considerable progress has been made by many large manufacturers. Tolerances should be as large as will result in satisfactory operation. The drawings and specifications should give tolerances. The author presents an analysis of data received from manufacturers regarding cost of inspection and percentage of scrapped parts. Comments from several manufacturers are also given.

Turning With Shallow Cuts at High Speeds. By H. J. French and T. G. Digges, respectively International Nickel Co., Bayonne, N. J., and Assistant Metallurgist, Bureau of Standards, Washington, D. C.

A method is described for testing lathe tools under shallow cuts and fine feeds. The relations were determined between the cutting speed, feed, depth of cut, and tool life for carbon and high-speed tool steels. Comparisons were made of tools of different forms and of tool life when cutting dry and with water or lard oil. Heat treatment and chemical composition of the tools were also studied, including in the case of high-speed tool steels, the effects of cobalt, nickel, molybdenum, arsenic, antimony, phosphorus, sulphur, copper, tin, aluminum, titanium, and tantalum. The results obtained under shallow cuts and fine feeds with these steels are compared with those obtained under heavy duty.

Performance of Oil-Ring Bearings. By George B. Karelitz, Research Engineer, Westinghouse Electric & Manufacturing Co., E. Pittsburgh, Pa.

This paper comprises notes on the performance of oil-ring lubricated bearings. The safety of the bearing, determined by the minimum oil-film thickness is discussed; a diagram for computation of this value is given. The end leakage and the amounts of oil supplied by oil rings are shown, the mechanism of operation of oil rings is described. The friction losses and the heat dissipation in oil-ring bearings are estimated, and a way to predetermine the temperature rise of a bearing is indicated.

A Test Code for High-Speed Steel for Turning Tools. By Lewis H. Kenney, United States Navy Yard, Philadelphia, Pa.

A test code applicable to high-speed tool steel intended for the manufacture of lathe and planer tools is given in this report. It covers such items as grinding, heat treatment, test forging, test cut, work done by cutting tool, tabulation of data, selective factor, and other similar ones.

Present Practice in the Use of Cutting Fluids. Compiled by S. A. McKee, Associate Mechanical Engineer, Friction and Lubrication Section, Bureau of Standards, Washington, D. C.

This report is an attempt to indicate, in so far as its scope will permit, either the trend or lack of trend, as the case may be, toward the use of a particular type of cutting agent for a given machining operation on a given kind of metal. It is based on information obtained from sixty-eight of the large users of cutting fluids in this country. Nine tables are presented. The first of these is a general summary. It lists the number of plants using any of three general types of cutting agent (dry, water or emulsions, oils or oil mixtures) for each of nineteen machining operations on eight kinds of metals. Each of the remaining eight tables gives more detailed information pertaining to the cutting agents used for the various operations on a given metal.

Present Status of the Mechanical-Spring Art. By Joseph Kaye Wood, Consulting Engineer, New York, N. Y.

In the past five years considerable progress has been made in the mechanical-spring art, due to the efforts of the A.S.M.E. Spring Research Committee and to other separate organizations, both commercial and otherwise, in this country and abroad. The main incentive for this progress might be indirectly traced to the activities of the A.S.M.E. Spring Research Committee and similar committees in other countries, particularly Great Britain. It is the purpose of this paper to assemble the high spots of this progress, describing briefly the results of each effort and their practical value to industry. The outstanding features of this progress are the improvement in helical- and conical-spring design and the better understanding of internal hysteresis in spring metals which promises to lead to more fundamental discoveries concerning the elasticity of metals. This paper also includes the unpublished results of the author's further research in the construction of a simplified code of design for mechanical springs. Notable advance has also been made in the actual determination of the modulus of elasticity for various kinds of spring material and in the characteristics of automotive leaf springs. Finally, the paper concludes with an outline of research that might well be contemplated for the future.

MANAGEMENT

Twelve Years' Experience With Economic Production Quantities. By C. H. Best, Supervisor of Materials, Eli Lilly & Co., Indianapolis, Ind.

For twelve years economic production quantities have governed the sizes of production orders in the plant of Eli Lilly & Co., manufacturers of pharmaceutical and biological products at Indianapolis, Ind. This paper outlines briefly some of the major results of this practice, both direct and indirect, and discusses some of the cost-accounting problems that were encountered in the derivation of the formulas. The discussion of cost-accounting problems is limited by the author to such problems as might be generally encountered in other plants.

Management of Service Department. By William B. Ferguson and Tom H. Blair, respectively former Production Manager, now Assistant to President, and Head of Time Study Dept., Newport News Shipbuilding & Dry Dock Co., Newport News, Va.

The organization and management of the service departments in a large plant with over 6000 employees doing a great variety of unstandardized work of fluctuating volume and spread over an area of 140 acres presents many difficult and complicated problems compared to similar problems in the usual manufacturing establishments. After the productive or operative departments in this plant had been reorganized and modern methods of planning, scheduling, production control, cost control, and wage-incentive plans had been put into effect over a period of about five years, then it became possible to undertake further improvements in the staff and service departments with respect to better organization, training of executives and employees, and measuring in some way, directly or indirectly, the value of the service rendered or the output of these service departments; and finally applying bonus plans or other wage-incentive schemes to reward the employees in these service departments, upward of 700 men and women, for improved efficiency.

The methods described are a result of over a year's previous study and preliminary work, and represent the simplest form of wage incentive that seemed practicable to apply to a large plant of this character. Since the first service department was put on a bonus system in April, 1928, there was a net saving during the first 15 months (that is, about four months after the last service department was put on a bonus system) of about $175,000 for the whole plant. The simple methods used have created a great interest on the part of heads of departments and employees in the service departments in further study and improvements along scientific lines, paving the way for still greater benefits, both to the employees and to the company. The main feature to be emphasized is that an opportunity has been and can be offered to *all* employees in *all* service departments for increasing their earnings in proportion to their results and thereby increasing the net earnings of the company to a much greater degree than has probably ever been appreciated. It is believed that this is the first record of such an accomplishment in a very large industrial plant.

Suggestions for Encouraging Education and Training for Industry. By Harold S. Falk, Vice-President and Works Manager, The Falk Corporation, Milwaukee, Wis.

Training of artisans and mechanics for American industry has been very much neglected in past years, and the movement for the revival of apprenticeship and industrial training can justly expect support from the engineering profession and The American Society of Mechanical Engineers because of the dependence of the profession upon efficient operations in industry. One of the great problems of apprenticeship and industrial training is to give the movement greater publicity, and to bring the subject before manufacturers and

business men. Because of its very great prestige in industry the Society can accomplish much in this direction.

Local branches of the Society can effectively promote the movement by holding contests of various kinds related to industrial training. Because of the interest of engineers in drafting work, a contest in skill for drafting apprentices is suggested.

Such a contest may be conducted by a local committee, and if given extensive publicity will be very effective. Another possibility for the local branches is to give an award for the best paper written by an engineer on an assigned subject in the field of industrial training. The successful papers might be read before meetings of local branches of the Society. Also local branches might award a medal or cup every year to the corporations in their respective communities which have made the greatest advance in industrial training in a given year. Such a contest might be the most effective of all, but would need to be more carefully directed than the others.

Contests of this kind could be carried on without extensive study or research, and experience in similar contest conducted under other auspices has proved that they are very effective for purposes of publicity. Through contests the influence of the Society would force attention to the problems of industrial training on those who are most directly concerned.

The Use of Economic Manufacturing Quantities. By Robert W. Kent, Vice-President, Bigelow, Kent, Willard & Co., Inc., Boston, Mass.

For the sake of establishing better manufacturing procedure, the author points out methods for determining how much to manufacture of a particular item or part at one time or in one lot. He discusses what is meant by economic manufacturing quantities, the aid toward increasing profits that come from use of proper formulas, and that minimum economic manufacturing cost can be obtained only through application of the principles made use of in developing a proper formula to fit each specific case.

Advantages Derived From the Simplification of the Fundamental Formulas for Economic Production Quantities. By Fairfield E. Raymond, Assistant Professor of Industrial Research, Massachusetts Institute of Technology, Cambridge, Mass.

This paper embraces a large amount of detail work, and includes many formulas for economic production quantities. The need for simplification of fundamental formulas is stressed, and various methods of applying the charts are given. The procedure for each case is described, and a complete presentation of mathematical principles is included. Some of the items discussed include selection of simplified forms, advantages of use of calculating sheets, methods of simplification, elimination of extraordinary factors, permissible variation in production quantities, index ratios, economic production quantities, limits of usefulness, and the problem index.

Engineers in American Life. By L. W. Wallace and J. E. Hannum, respectively Executive Secretary, American Engineering Council, Washington, D. C., and Editor, A.S.M.E. Engineering Index Service, New York, N. Y.

Herbert Spencer once said: "What knowledge is of most worth? The uniform reply is Science. This is the verdict on all counts."

With this thesis in mind, an effort has been made to determine the degree to which the scientific method has penetrated American life as measured by the activities of the men of science listed in "Who's Who in America." Thirty per cent of all those so listed are scientists. Engineers and architects comprise nine and nine-tenths per cent of the total number.

A careful analysis has been made of the biographies of the engineers. The paper will show the scope of the cultural and professional education and activity of these men; the positions they hold; the total assets and gross earnings of the organizations which they direct; their varied interests as shown by their connection with organizations and projects lying without the engineering field; the degree to which they direct municipal, state, and Federal governments as indicated by the governmental positions they hold; the amount of Federal moneys they expend.

These and many other exceedingly illuminating facts will be presented. From this analysis the conclusion is that engineers are not narrow in their cultural and professional training and interest; that the scientific method has broadly permeated American life; and that the philosopher quoted gave to the people of the world a sound basis for their social, moral, economic, and political development and stability.

MATERIALS HANDLING

The Application of Aerial Tramways to Long and Short Hauls. By M. P. Morrison, Tramway Engineer, American Steel & Wire Co., Worcester, Mass.

The use of aerial tramways for materials handling is of advantage where no other means of transportation is possible, and where difficulties of an engineering nature are to be overcome. Advantages over other methods include independence of weather conditions, independence of ground conditions to avoid expensive tunneling or trestle work, and easy protection of property. The length and capacity of aerial tramways are unlimited from an engineering standpoint, but extreme length and capacity are sometimes limited by commercial conditions. Several tramways of special designs are described.

Economic Aspects of Gasoline-Operated Commercial Vehicles. By R. E. Plimpton, Associate Editor, *Bus Transportation*, Chicago, Ill.

A recent treatise on the development of electric service in the small towns and rural districts contains the following significant statement: "The ability to ship by truck or rail to and from any point and available power supply at almost any place has made it possible for American industry to remove and remold itself at will."

Taking this pronouncement as a text, the paper discusses the motor truck operated over the public highways as applied to the service of industrial plants. The economic place of the truck is approached from two angles:

1 Its function in promoting: (*a*) the flow of raw and semi-finished materials from their source into the factory or plant; (*b*) in the movement between plants under a single control or out to decentralized warehouses or branches; and (*c*) in the final distribution to customers or consumers.

2 The ownership of the trucks thus engaged: as (*a*) by the industrial plant itself; or (*b*) by outside specialists working either as contract or common carriers.

If the trucks are owned their operation and maintenance may be assigned to various plant departments or even to a subsidiary company. The conditions that must be considered in determining the preferred type of organization are considered.

In conclusion the paper takes up at some length the growth of motor-freight companies. It emphasizes their relation to industrial plants, particularly of the type manufacturing goods shipped in small lots and sold through outlets dealing directly with the general public.

The Economics of the Electric Truck in Delivery Service. By Charles R. Skinner, Jr., Manager, Automotive Division, Industrial Sales Bureau, N. Y. Edison Co., N. Y.

The operating characteristics of the electric truck are described and its place as an economic factor in modern business explained. The use of the electric truck for city service is constantly increasing according to the author, and where it is used in fields for which it is suited it is proving entirely satisfactory to its owners. Manufacturers in selling the electric today are careful to see that the proposed service is within its scope. If the work is not that of the electric, they are among the first to warn the prospective purchaser that he is apt to be disappointed. This enlightened sales policy explains in a large measure why users are the most enthusiastic endorsers of electrics. The largest single user of electric trucks in the country is the Railway Express Agency, and the executives of this organization have been most enthusiastic. Other large users are the department stores, the ice manufacturers, the storage warehouse owners, the dairies, the big baking companies, and the laundries. Operating records of electrics in these various fields are included.

OIL AND GAS

The Service Characteristics of Diesel-Engine Lubricating Oil. By A. E. Flowers and M. A. Dietrich, respectively Engineer in Charge of Development, DeLaval Separator Co., and Process Laboratory, DeLaval Separator Co., Poughkeepsie, N. Y.

In this paper the authors give the results of a study of the record and characteristics of the lubricating oil used in a Diesel engine oper-

ating a Diesel-electric locomotive of the New York Central Railroad. Test methods are outlined, and the characteristic changes in the oil are given. The character of the sludge from Diesel-engine lubricating oil is discussed, and methods of purification and reclamation are given.

PETROLEUM

Engineering and the Oil Industry. By George L. Reid, Joseph Reid Gas Engine Co., Oil City, Pa.

The oil industry in the United States has the largest investment of any industry excepting agriculture. It is twice as large as steel and is increasing its investment at five times the rate of the steel industry. Its tremendous scope includes nearly all branches of science and engineering activity but it has only been within relatively recent years that it has called upon the scientist and engineer for guidance.

Drilling methods have been put on a comparatively sound engineering basis. Production methods, however, are only beginning to partake of the scientific attitude. This is especially marked in the application of engineering methods relative to oil production.

Of primary importance in the lifting of oil is the single-cylinder horizontal-type gas engine. This type of engine, which is delivering over one and three-quarter millions of horsepower, has undergone many refinements worthy of the attention of engineers. Its various applications directly to the process of oil lift bring out many problems that must, in the future, receive intelligent engineering study.

Driven by the internal-combustion engine, the bandwheel power has become an established unit in the oil field. Its construction and application is as worthy of note and subject to as great engineering and research problems as the internal-combustion engine.

Performance of Modern Steam-Generating Units. By C. F. Hirshfeld and G. U. Moran, respectively Chief, Research Department, and Research Department, Detroit Edison Co., Detroit, Mich.

There has been much speculation during the past as to those factors which seem to be most responsible for steam-generating unit outage. This is a question which always arises when a plant is being designed for a certain capacity factor, where the reliability or availability of the boiler units must be accurately foreseen.

Some have held that the outage increases directly with the severity of use. Others contend that the method of burning the fuel has a definite bearing on reliability. Others still have set different values for unit reliability on different kinds of fuel.

As the probable availability of units operating under certain conditions is a matter of utmost importance to the power-station designer and owner, it was thought that a complete and thorough study of the facts obtaining in the power-generating industry would be of great value. With that idea in mind the authors were requested by the Central Stations Committee of the Power Division to prepare this paper.

The study was made along the same general lines as the steam-turbine investigation made by the Prime Movers Committee of the N.E.L.A. The methods used in collecting information were as nearly identical as circumstances and the character of the units studied would permit. Daily operation logs were filled out for the period of one year by the operators of some two hundred boilers scattered about the country in sixty-odd stations. The data resulting were compiled by one group of men in such a manner that the results might be readily compared. These compilations are shown in both tabular and graphic form.

The units have been arranged in groups or classes according to methods of fuel burning and the working steam pressures, and then numbered in order according to their average rates of evaporation. With the data arranged in such a manner it has been possible to arrive at some rather definite conclusions.

RAILROADS

Locomotive Auxiliary Power Mediums. By George W. Armstrong, Bethlehem Steel Co., Bethlehem, Pa.

This paper describes the Bethlehem auxiliary locomotive. It is a self-contained auxiliary-power truck, which can replace one of the regular tender trucks. It can be used either as a front or back truck, or in some instances to replace both. Ordinarily the rear-truck installation is recommended as it facilitates removal for inspection and maintenance. Test results are included.

Heat Transfer in the Locomotive Superheater. By Lawford H. Fry, Metallurgical Engineer, Standard Steel Works Co., Burnham, Pa.

The present paper extends the author's method for calculating heat transfer in locomotive flues and shows how it can be applied to determine the heat transfer in the superheater flues and tubes.

To illustrate the scope and accuracy of the method, it is applied to three sets of experimental data obtained from two locomotives on the Altoona locomotive test plant. For one locomotive, Class K2sa, No. 877, with a type A superheater, the test represents a high rate of operation with 50,000 lb. of water evaporated per hour, while for the other locomotive, Class M1s, No. 4700, the two tests with 65,000 and 35,000 lb. of water per hour represent respectively high and low power. In each of these cases the firebox temperature and the rate of flow of the gases of combustion through the flues are taken as points of departure. The Fry method is used to calculate:

a The temperature along the evaporative flues, and
b The temperature drop along the superheater flues.

These together enable the average smokebox temperature to be computed and compared with those found experimentally.

c The transfer of heat to the evaporative surface of the flues containing the superheater pipes, and
d The transfer of heat to the superheater pipes.

The last item represents the heat used to superheat the steam, and can be compared with the amount of superheat found experimentally.

The result of the calculations indicated are shown in tabular form in comparison with the observed results.

The Design and Application of Rail Motor Cars. By C. O. Guernsey, J. G. Brill Co., Philadelphia, Pa.

Rail motor cars are now being used in many classes of service. Sizes are from 70 to 800 hp. Those of 200 hp. or less are generally of mechanical type and are now being manufactured mostly for export. Larger sizes are of gas-electric type. The engine, generator, traction motors, cooling system, car weight, etc., must bear the proper relation to each other to get satisfactory results. Engine advantages include horsepower ratings, engine speeds, cylinder head and valve design, bearings, oiling system, water and oil cooling, water circulation, fuel-feeding systems, exhaust manifolds, oil filters, and intake manifolding.

The manufacturer, as a result of experience on numerous properties throughout the world is able to get a breadth of experience which cannot be accumulated on any one railroad. He is able to keep step, so that his product represents combined experience on all properties operating that product; further, the design and development of any new size or type of equipment represents a tremendous expenditure for engineering, patterns, dies, tools, jigs, fixtures, and experimental work, which the manufacturer can prorate over a large number of equipments. Where special features are specified and insisted upon by an individual purchaser, he may not only throw the design badly out of balance, but also seriously increase the cost.

Metallurgy in the Railroad Field. By Charles McKnight, Metallurgist, International Nickel Co., New York, N. Y.

There is increased interest in and use of alloy steels by railroads. They are used purely as a matter of economics. Better work must be done at the same cost or the same work at less cost. The use of alloy miscellaneous castings cuts down weight 40 per cent with the same strength and same cost as carbon-steel castings. There are three ranges of steels; carbon steels are used for the vast majority of railroad purposes, with alloy steels for special applications, and semi-alloy steels, which are slightly more expensive than carbon steels and with slightly better properties, as a compromise. Some of their uses include boiler materials, forgings, and castings. Corrosion, nitriding, light alloys, and miscellaneous metals are discussed and the economics of operation are given.

High-Pressure Locomotives. By Albert F. Stuebing, Chief Engineer, Bradford Corporation, New York, N. Y.

This paper discusses two types of high-pressure locomotives recently built, the Loeffler type and the Winterthur locomotive. The

former is an express locomotive of about 2500 hp. with a pressure of 1470 lb. per sq. in , and the latter of about 1200 hp. with a boiler pressure of 850 lb. per sq. in. The Loeffler locomotive is expected to result in a fuel saving of from 40 to 45 per cent compared with modern superheated locomotives. In a road test of the Winterthur locomotive, but 330 lb. of coal was necessary for firing up as compared with double that amount which was necessary for a conventional locomotive of equivalent output.

TEXTILE

General Design and Operating Features of Range or In-Train Drives for Finishing Plants. By Wendell S. Brown, Engineer, with F. P. Sheldon & Son, Providence, R. I.

Marked progress is developing along the lines of grouping finishing-plant machinery in series or in ranges. This, among other important advantages, secures elimination of intermediate handling.

Range drives may be divided into three classes according to the method adopted for driving the individual units or groups. They are:

Class 1—Variable-speed motors, which includes direct-current constant-voltage equipment, direct-current multivoltage equipment, and alternating-current equipment.

Class 2—Constant-speed motors or mechanically driven shafts, speed variation being obtained through such a device as the mechanical variator.

Class 3—Variable-speed steam engine.

Range drives prove advantageous in many combinations, from cloth in the rope form to cloth in the open form—examples are given.

The successful operation of finishing machinery in ranges is dependent upon the attainment of certain advantages, such as elimination of "in-between-losses" improved uniformity in quality of product, saving in power and maintenance expense, and saving in executive and office work.

There are also certain possible disadvantages which must be taken into account for each individual case, such as the present market tendency toward a multiplicity of small lots and varied styles, and the demand for samples; range speeds limited to that of the slowest member, breakdowns tie up production, additional building construction to accommodate extra length, operating losses due to cloth damage in earlier processes continuing unnecessarily through subsequent processes, and somewhat greater initial expense.

WOOD INDUSTRIES

From the Master Cabinetmakers to Woodworking Machinery. By J. D. Wallace, President, J. D. Wallace & Co., and Margaret S. Wallace, Chicago, Ill.

This paper gives a history of woodworking machinery from early times up to the present. Various types of furniture with carving, ornamentation, and decoration had an influence on the particular types of machinery and tools that were used in different periods. Early furniture was hand-made, but mass-production requirements of present times have changed matters entirely. Beautiful furniture is now machine-made, and many changes in design have been necessary to permit use of modern industrial methods.

Modern Method of Manufacturing Classical Furniture. By Harry Kimp, Superintendent and Designer, Chesterfield Furniture Co., Long Island City, N. Y.

The modern method of manufacturing classical furniture eliminates nearly all hand operation and is simplified by the use of a board on which are mounted full-size drawings from which measurements are taken by workmen for the construction of each piece in a suite. The author describes the process from preparing and drying of lumber through the various machine operations to the completed furniture, preparatory to shipment.

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(49) A Test Code for High-Speed Steel for Turning Tools, L. H. Kenney. Report of Sub-Committee D on Properties of Materials of the Special Research Committee on Cutting of Metals

(50) Present Practice in the Use of Cutting Fluids, S. A. McKee. Progress Report No. 2 of Sub-Committee on Cutting Fluids

(51) Elastic and Inelastic Behavior in Spring Materials, M. F. Sayre. Fifth Progress Report of Special Research Committee on Mechanical Springs

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AGRICULTURE

Mechanical Engineering Applied to. The Application of Mechanical Engineering to Agriculture, J. G. B. Sams. Engineering (Lond.), vol. 148, no. 3838, Aug. 2, 1929, pp. 112–114, 1 fig. Discussion is limited to working of larger farms and fields; mechanical ploughing, sowing, and harvesting; simple mowing machines; carting; threshing and threshing machines; electrical driving.

AIR CONDITIONING

Fundamentals. The Fundamentals of Air Conditioning, E. Bolling. Heat, Piping, and Air Conditioning, vol. 1, no. 5, Sept. 1929, pp. 361–372, 8 figs. Résumé of principles and practice of modern air conditioning; properties of air; absolute and relative humidity moistening, drying, heating, and cooling effect of air; humidification control.

Heat and Moisture Losses From Body. Heat and Moisture Losses From the Human Body and Their Relation to Air Conditioning Problems, F. C. Houghten, W. W. Teague, W. E. Miller, and W. P. Yant. Heat., Piping, and Air Conditioning, vol. 1, no. 5, Sept. 1929, pp. 429–432, 6 figs. Review of work completed by laboratory of Am. Soc. Heating and Ventilating Eng. with cooperation of U. S. Bur. of Mines giving test procedure, observations, and typical problems.

AIRPLANE ENGINES

Bearings. Ball and Roller Bearings in Aircraft Engines, D. E. Batesole. Aviation Eng., vol. 2, no. 8, Aug. 1929, pp. 14–17, 13 figs. Applications of anti-friction bearings to airplane engines are discussed; radial engines particularly well adapted to mounting of anti-friction bearings; types of bearings used; selection of engine bearings based on new formulas; crankshaft and connecting rod bearing applications; supercharger bearings called upon to meet unusual requirements; rocker-arm bearings; ball bearings used extensively in engine accessories.

Manufacture. Nickel Cast Iron Engine Cylinders, E. J. Bothwell. Aero Digest, vol. 15, no. 1, July 1929, pp. 104–106, 5 figs. Use of cast iron for aircraft-engine cylinders is discussed; function of nickel in bringing about desired improvements in cast iron is taken up; experience with a few engines using nickel cast iron cylinders is related, including Hurricane, Brownback, and Wright airplane engines.

AIRPLANES

Aluminum Alloys for. Service Characteristics of Light Alloys, E. H. Dix, Jr., Am. Mach., vol. 71, no. 11, Sept. 12, 1929, pp. 441–444, 3 figs. Summary of improvements made in aluminum- and magnesium-base materials to increase strength and reduce corrosion; artificial aging of certain of heat-treatable aluminum alloys at elevated temperature to produce maximum strength and hardness; results of experiments with aluminum-copper-magnesium-silicide alloy, production of Alclad. Abstract of paper presented before Soc. Automotive Engrs.

Autogiro. See AUTOGIROS.

Brakes, Pneumatic. Air Pressure Brakes and Pneumatic Steering for Airplanes (Druckluftbremse und Druckluftlenkung fuer Landflugzeuge), T. Kollinek. Luftfahrt (Berlin), vol. 33, no. 5, Mar. 7, 1929, pp. 71–73, 3 figs. Equipment developed by Knorr Brake Co. in Germany for braking and steering plane in landing is described; tests, carried out in conjunction with Junkers Works, have proved that taxying can be reduced to one-third and turning at any speed can be obtained without danger.

Gasoline Strainer for. An Aircraft Gasoline Strainer. Airway Age, vol. 10, no. 9, Sept. 1929, p. 1494, 1 fig. Description of aluminum strainer for airplanes designed by Lunkenheimer Co., Cincinnati, Ohio; drain valve has been made part of body and not part of cap; drive may be piped off to outside of fuselage and does not interfere with removal of strainer assembly.

Landing Gear, Amphibion. The Loening Monowheel Amphibion Gear. Aero Digest, vol. 15, no. 2, Aug. 1929, p. 138, 1 fig. Description of new monowheel amphibion device developed by Grover Loening which was fitted to standard Moth biplane; gear consists of single main float 17¹/₂ ft. long, 30 in. wide, and side floats of welded duralumin construction; single wheel mechanism raises and lowers in pocket in hull; its operation is synchronized with that of doors that open and close pocket according to position of wheel.

Metal Construction. British Methods of Steel Aircraft Construction, W. H. Sayers. Aviation, vol. 27, no. 7, Aug. 17, 1929, pp. 370–374, 17 figs. Work of British firms, which have contributed to development of steel aircraft construction, is outlined; Boulton and Paul mixed is used for more heavily loaded members and light alloys in members less heavily stressed; modern spar made from annealed strip hardened and tempered after forming; construction of fittings; tubular sections for internal drag struts and ribs; stainless steel construction; metal construction developed by Bristol Aeroplane and H. G. Hawker Companies.

Metal Construction Development, H. J. Pollard. Nat. Advisory Committee for Aeronautics—Technical Memorandums, nos. 526–529, Parts I–IV, Aug.-Sept., 1929, in all 87 pp. and 62 figs. Part I: Tendency of steel constructions for airplanes and type of construction which should ultimately give best results; savings in weight secured by strip construction; detail design to make construction inexpensive; three essentials necessary before starting strip construction; thickness of both steel and duralumin as coverings; metal strip construction of fuselage. Part II: Considerations which will help technician to succeed in designing wing spars or other structural members in thin metal; stresses in spars; tests for Bristol Aeroplane Co.; of factors in desired formulas, radius of gyration of section is most important; special cases of spar construction developed by Bristol Aeroplane Co.; tapered spar for Bristol Brownie. Part III: Workshop practice and several methods of forming sections of strip into airplane parts; forming heat-treated high-tensile steel strip by rolling and drawing; problem of spring back; finishing tools; selection of stages from flat strip to final tool; die and roll making; assembly of section into structural members; wing rib manufacture. Part IV: Calculation of moments of inertia of beams made up of corrugated strip of small thickness; moment of inertia of flange about central axis of spar and of web about same axis calculated; method of determining fiber stresses in spar when given loads come on to it; stress at which elastic instability is likely to set in must be estimated for flanges and webs by finding radius of gyration around various axes.

Penaud vs. Canard Type. The Penaud Versus the Canard Types, A. Merrill. Aviation, vol. 27, no. 7, Aug. 17, 1929, p. 369, 1 fig. Comparison of Penaud system of surfaces spaced apart fore and aft, front surface or surfaces being supporting means, rear surface acting as stabilizer, and of Canard type system of surfaces spaced apart fore and aft, rear surface or surfaces being supporting means, front surface acting as stabilizer; graph shows variation of lift and drag in pounds with angle of attack.

Performance Calculation. The Induced Drag Viewpoint of Performance, C. B. Millikan.

NOTE.—The abbreviations used in indexing are as follows:
Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

Aviation, vol. 27, no. 7, Aug. 17, 1929, pp. 364-368, 1 fig. Standard formulas for calculation of airplane performance relating to power required are stated in form which brings out nature of physical dependence of phenomena on two aerodynamic parameters, namely, span loading and parasite loading; difficulties in getting accurate analytical expressions for power available in general are shown to disappear in large measure for case of high-speed level flight; formula for maximum speed involves two aerodynamic parameters and thrust power loading.

Propeller Design. The Construction of Propeller Polars (Die Konstruktion der Propellerpolaren), T. Troller. Zeit. fuer Flugtechnik u. Motorluftschiffahrt (Munich), vol. 20, no. 12, June 28, 1929, pp. 303-306, 4 figs. Graphical method is developed for constructing polar curve of efficiency of propellers; problem of determining blade width, incidence-angle and section requisite to develop stipulated thrust and given revolutions and speed of advance is considered in detail.

Seaplanes. See SEAPLANES.

Steering. Airplane With Wing Steering (Flugzeug mit Fluegelsteuerung), M. Ono. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 20, no. 9, May 14, 1929, pp. 224-227, 4 figs. Curves and conclusions of tests by which it is shown that steering can be carried out without elevating rudder.

Struts. Aerodynamic Theory and Test of Strut Forms, R. H. Smith. Nat. Advisory Committee for Aeronautics—Report, no. 311, 1929, 24 pp., 12 figs. Symmetrical inviscid flow about empirical strut of high service merit is found by both Rankine and Joukowsky methods, theoretical stream surfaces as well as surfaces of constant speed and pressure in fluid about strut determined; surface pressure computed agrees well with measured pressure on fore part of model, but not so well on after part; surface friction; drag integrated from friction and measured pressure closely equals whole measured drag. Bibliography.

Tail Skids. Tests With New Form of Tail Skid (Versuche mit einer neuen Spornform fuer Flugzeuge), F. Michael. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 20, no. 13, July 15, 1929, pp. 329-334, 13 figs. Investigation of DVL (German Testing Institute for Aviation) with regard to defects in existing types, actual requirements and possible improvements; rolling and landing tests with different types developed by DVL on various fields, show that only little change will be required in existing types used on transport planes in order to obtain better preservation of landing fields.

Weight Control. Airplane Weight Control, J. F. Hardecker and B. E. Lambert. Airway Age, vol. 10, no. 9, Sept. 1929, pp. 1401-1403, 3 figs. Problem of weight control in airplane design is taken up; eternal vigilance of designer necessary to keep airplane weight down to minimum; weight control divided into five phases; group weight allowances; breakdown of weight; detail weight allowances.

Weight Control in the Design of Aircraft, F. Flader. Aviation, vol. 27, no. 7, Aug. 17, 1929, pp. 360-363, 5 figs. Importance of weight as opposed to resistance for particular aircraft must be determined by designer; laxity in accurate prediction of weights of component parts of plane in design stage leads to very undesirable effects; method of weight control employed by Consolidated Aircraft Corp. in connection with development of Admiral PY-1 Navy Patrol flying boat is described; estimated and actual weight statement; computed weight empty.

AIRPORTS

Design. The Design of Airports, R. Saal. Surveyor (Lond.), vol. 76, no. 1962, Aug. 30, 1929, p. 189. Templehof Airdrome in Berlin, Germany, is described as best outstanding example of modern airport; unusual features are pointed out; consideration is given to area, location, drainage, fog, and smoke hazards.

Planning. Fundamental Considerations With Regard to Airport Construction (Grundsaetzliches ueber Flughafenbau), E. Dierbach. V.D.I. Zeit. (Berlin), vol. 73, no. 32, Aug. 10, 1929, pp. 1125-1130, 9 figs. Fundamental principles in design of mooring masts and hangars for airships; landing and starting fields; shore installations of sea airports; currents and surf; some typical hangars for airplanes; standardization in design of dispatching hangars.

AIRSHIPS

England. The British Airship R. 101 (Das britische Luftschiff "R.101"). Maschinen-Konstrukteur (Berlin), vol. 62, no. 16, Aug. 15, 1929, pp. 375-376, 2 figs. Short description of airship and its 8-cylinder Beardmore Diesel engine of 650 hp.; dimensions of ship are as follows: length 221 m.; diameter 40.14 m.; contents 142,000 cu. m.

ALLOYS

Aluminum. See AIRPLANES, Aluminum Alloys for; ALUMINUM ALLOYS.

Iron. See IRON ALLOYS.

ALUMINUM ALLOYS

Aluminum Bronze Manufacture. The Manufacture of Aluminum Bronze, C. E. Margerum and L. H. Fawcett. Heat Treating and Forging, vol. 15, no. 9, Sept. 1929, pp. 1164-1166, 3 figs. Description of methods of manufacturing aluminum bronze that are employed in United States Naval Gun Factory at Washington when using 10-in. diam. mold; shrinkage cavity confined to hot top; melting procedure, forging, and heat treatment are outlined; tables of chemical analysis and mechanical properties of forging, and of composition, heat treatment, and scleroscope measurements are given.

Castings. Pinholes in Cast Aluminum Alloys, N. F. Budgen. Inst. of Metals—Advance Paper (Lond.), no. 501, for mtg. Sept. 9-12, 1929, 14 pp., 20 figs. Paper describes investigation into causes of pinholes in sand-cast aluminum alloys, and describes various forms of pinholes that are seen; notes are confined largely to observation of sand-cast test-blocks 3 in. in diam. by 3 in. deep; influence of aluminum ingot itself, melting and pouring temperature, time maintained molten, melting fuel and furnace, rate of solidification, turbulence of pouring, and allowing elements are separately considered in relation to their effect on pinholing; means for preventing pinholes are described.

Regulated Control in Heat-Treating Aluminum-Alloy Castings. Am. Mach., vol. 71, no. 10, Sept. 5, 1929, p. 403, 2 figs. Method used by Aluminum Company of America to heat-treat and test castings of aluminum alloys under nearly automatic conditions is illustrated.

AUTOGIROS

Cierva. Improved Cierva Autogiro Tested in Flight by Inventor, H. Hosking. Automotive Industries, vol. 61, no. 9, Aug. 31, 1929, pp. 302-303 and 306, 3 figs. Description of improvements made in Autogiro; new tail structure, consisting of conventional elevator with second fixed horizontal plane below it, has been added to model originally tried in England; raised center of gravity resulting from addition of rotor and shaft is compensated by dihedral wing tips with pitch of approximately 135 deg.; fuselage of conventional design, shortened in test plane to 15 ft.

AUTOMOBILE ENGINES

Carburetors. For Better Vaporisation. Motor Transport (Lond.), vol. 49, no. 1271, July 22, 1929, p. 112, 2 figs. Chief feature of design of new Apex carburetor is surface evaporation principle used in old surface and wick-type carburetors; device for vaporization is termed bulb, and consists of knurled gun metal surrounded with absorbent wire gauze covering, comparison of results of this type with other types.

Design. Kinematics of Valve Drives of High Speed Motors (Die Kinematik des Ventilantriebs bei sehr schnellaufenden Motoren), O. Holm. Automobiltechnische Zeit. (Berlin), vol. 32, no. 20, July 20, 1929, pp. 425-428, 4 figs. Graphical and mathematical development for calculation and design of automotive engines.

AUTOMOBILE PLANTS

Foundries. To Melt 2200 Tons of Iron a Day, F. L. Prentiss. Iron Age, vol. 124, no. 10, Sept. 5, 1929, pp. 612-614, 4 figs. Description of enlarged gray-iron foundry of Chevrolet Motor Co., which has 11 cupolas and 14 continuous molding and pouring conveyors; method of handling castings between shake-out and cleaning room; sand-handling system carries many tons; three melting units always fired.

Heat-Treating Departments. Uses Universal Heat-Treating Unit, F. W. Manker. Iron Age, vol. 124, no. 11, Sept. 12, 1929, pp. 663-666, 5 figs. Description of heat-treating units according to operation by Packard Motor Co., Detroit; three furnaces, with pushers and pullers interconnected with time controls, forming one continuous and automatic outfit; by altering time cycles and temperatures of various units, all sizes of work, from small forgings up to large axles, can be treated interchangeably.

Materials Handling in. Materials Handled Economically, J. R. Sullivan. Iron Age, vol. 124, no. 10, Sept. 5, 1929, pp. 593-596, 6 figs. Discussion of marked savings obtained by Studebaker Corp. from operation of transportation department employing 200 men and like number of equipment units; trucks handle overflow from conveyors; schedule based on number of cars produced; 60 per cent saved in hauling refuse sand.

AUTOMOBILES

Design. Protection of Streets Through Design of Automotive Vehicles (Schonung der Strassen durch die Konstruktion der Kraftfahrzeuge) Wawrziniok. Verkehrstechnik (Berlin), nos. 11, 12, and 13, Mar. 15, 22, and 29, 1929, pp. 179-182 and 195-199 and 209-216, 17 figs. List of descriptive factors affecting street surfaces; distribution of load on frame of vehicle; total pressure and specific aerial pressure of wheels on roadway; design and make of wheel tires; methods of braking; overloading of vehicles; distribution of load on wheels; relation between weight of vehicle and load; deductions as to design of vehicles and their operation with view of preserving and safeguarding of road surfaces.

Front-Wheel Drive. An American F.W.D. Car. Autocar (Lond.), vol. 63, no. 1764, Aug. 23, 1929, pp. 366-367, 2 figs. Description of American automobile with front-wheel drive, Lycoming engine rated at 33.8 hp.; frame is straight and is stiffened amidships by gigantic X-shaped girder, while front wheels are each sprung on two quarter-elliptic leaf springs, one clipped to top, other to bottom of frame; low chassis.

Manufacture—Forging and Heat Treating. Forging and Treating Parts for the Nash, C. Longenecker. Heat Treating and Forging, vol. 15, no. 9, Sept. 1929, pp. 1157-1159 and 1242, 6 figs. Description of procedure and equipment employed in heat-treating and forging departments at Kenosha plant of Nash Motors Co.; 25 steam drop hammers, ranging in size from 1000 lb. to 6000 lb. and 7 board hammers of 1000 lb. to 2000 lb.; carburizing furnaces; small parts refined in 14 furnaces of hump type, and large parts in rotary-hearth type electric furnaces.

Studebaker Methods of Forging and Heat-Treating, F. J. Oliver, Jr. Am. Mach., vol. 71, no. 10, Sept. 5, 1929, pp. 383-388, 14 figs. Forging and heat-treating departments of Studebaker plant in South Bend, Indiana, are discussed, throughout forge shop arrangement of equipment is such that there is even flow of material between machines and furnaces; arrangement for producing "Dictator 6" rear axles; layout for forging Studebaker and Pierce Arrow crankshafts; heat-treating connecting rods.

Shock Absorbers. Gemmer Pneumatic Shock Absorber Resembles Double-Acting Pump. Automotive Industries, vol. 61, no. 8, Aug. 24, 1929, pp. 261-262, 4 figs. Brief description of new controller-type absorber using air as cushioning element and vacuum to control rebound; piston is composed of two cupped leather washers impregnated with lubricant and specially treated and two spring steel spreaders for washers mounted on die casting.

Springs. Compound Springs Used in the Farman (Compound-Federung und Doppelenkung am Farman-Wagen), Oppenheim. Motorwagen (Berlin), vol. 32, no. 15, May 31, 1929, pp. 323-324, 6 figs. Old problem of uniform spring action with varying loads has been solved in case of Farman by use of compound springs connected to chassis by means of roads, assuring safety in case front spring should break; spring consists of large cross spring augmented by two cantilever springs; cross spring will take care of all normal loads while cantilevers are brought into play by unsymmetric forces or overloads.

The Case for the Independently Sprung Wheel, W. M. Evans. Automobile Engr. (Lond.), vol. 19, no. 257, Aug. 1929, pp. 308-312, 22 figs. Main factors effecting complex problem of automobile suspension; comparison of unsprung weight on regular type front axle and independently sprung wheel system; criticisms of latter system.

Wear of Parts. Wear in Automobile Parts (Wie nutzen sich die Teile eines Kraftwagens ab), O. Kienzle. Motorwagen (Berlin), vol. 32, no. 18, June 30, 1929, pp. 369-373, 5 figs. One of chief difficulties in spread of automobile in Germany is wear of parts and resulting breakdowns evidenced after car has been in use for 30,000 mi.; solution to problem depends not only on materials employed in construction but also on tolerances and fits employed; distinct relation exists between wear and amount of motion of part; author concludes that life of car for equal distances traveled varies inversely as tolerances adhered to.

AUTOMOTIVE FUELS

Alcohol. Alcohol Fuels for Use in Internal Combustion Engines, J. G. King and A. B. Manning. Instn. Petroleum Technologists—Jl. (Lond.), vol. 15, no. 74, June 1929, pp. 350-368, 20 figs. Results of experiments designed to

indicate limiting factors in preparation of fuels, and to show how these fuels would behave in ordinary standard gasoline engine are given.

Detonation. Anti - Knock Consumption. Petroleum Times (Lond.), vol. 22, no. 555, Aug. 31, 1929, p. 390. Makers of car engine are producing some part if not whole of their engine output for use at high compression ratios; this applies to new output only; old models are not of high compression type and are not suitable for giving greatly improved performance by use of fuel of high anti-knock value; canvassing 750 oil jobbers in United States by Petroleum Age, nearly 40 per cent. returns received from questionnaires; proportion of gasoline business done in special anti-knock motor fuels was 22.3 per cent of whole; regarded as fairly satisfactory result of propaganda.

B

BEARINGS, ROLLER

Railway. The Design, Application and Operation of Railway Roller Bearings. Ry. Engr. (Lond.), vol. 50, no. 596, Sept. 1929, pp. 352–356, 14 figs. Brief account of roller-bearing development in railroad work; tapered roller bearing principle; diagram showing theory and design of tapered roller bearings; description of bearing application. Abstract of paper presented before Cleveland Railway Club.

BENDING ROLLS

Design. Calculations for Bending Rolls, R. Tilkin. Iron Age, vol. 124, no. 9, Aug. 29, 1929, pp. 546–548. Calculations of formulas for establishing diameter with definite deflection and unit stresses, and determination of limiting conditions.

BOILER FEEDWATER

Treatment. Feed Water De-Aerator. Engineering (Lond.), vol. 128, no. 3320, Aug. 30, 1929, p. 275, 4 figs. Deaerator described is entirely self-contained; water from hot well enters at top through float-controlled throttle valve; air driven off is extracted by steam jet; float gear is practically friction free.

Improved Equipment for the Treatment of Feed Water for Modern Steam Boilers, J. D. Yoder. Indus. and Eng. Chemistry, vol. 21, no. 9, Sept. 1929, pp. 829–834, 7 figs. Importance of proper feedwater treatment for modern high-pressure boiler which frequently operates at 400 to 1200 lb. per sq. in. pressure; value of research investigations of Parr and Straub, Hall and Foulk; conclusion is drawn that modern high-pressure, high-rating boilers can be operated with satisfaction if proper equipment is installed for treatment of boiler feedwater and if it is operated in accord with recent disclosures of various water-purification engineers.

Modern Feedwater Treatment (Neuzeitliche Speisewasser-auf-bereitung), K. Hofer. Glueckauf (Essen), vol. 65, no. 31, Aug. 3, 1929, pp. 1067–1071, 2 figs. Prevention of corrosion and scale formation curves showing required carbonate concentration; prevention of brittleness in riveted boiler through cold stretching and loading over stretch limit; gas controls and density of boiler water are discussed.

Zeolite-Deconcentrator Combination for Boiler Water Purification, E. W. Scarritt. Indus. and Eng. Chemistry, vol. 21, no. 9, Sept. 1929, pp. 821–823, 3 figs. Use of zeolite water softener operating in combination with deconcentrating equipment eliminates undesirable features of zeolite-softened water for boiler feed purposes, reduces operating cost, minimizes blowdown, and provides clean boiler water which will produce clean steam; results obtained with combination system covering period of 200 days under boiler room conditions are shown with accompanying curves and tables.

BOILER FURNACES

Grates. Automatic Traveling Grate Firing for Steam Boilers (Selbsttaetige Wanderrostfeuerung fuer Dampfkessel), R. Bosselmann. V.D.I. Zeit. (Berlin), vol. 73, no. 30, July 27, 1929, pp. 1051–1055, 23 figs. New type with automatic control of feed dependent on degree of combustion of coals at end of grate and control of flue gas damper depending on boiler steam pressure.

Water-Cooled. Some Economic Considerations of Water Wall Installations, O. Craig. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 7–10, 1929, 7 pp., 1 fig. Discussion of various types of water-cooled walls, and factors which influence installations; effect of temperature in furnaces fired by pulverized coal; examples of typical installations are given with results obtained.

BOILERS

Corrosion in. Mechanism of Formation of Calcium Sulfate Boiler Scale, E. P. Partridge, and A. H. White. Indus. and Eng. Chemistry, vol. 21, no. 9, Sept. 1929, pp. 834–838, 12 figs. New theory of scale formation on boiler heating surface is presented; this theory states that initial deposition of scale crystals takes place directly on surface as result of formation of steam bubbles; bubble evolution theory of scale formation discredits "colloidal" theory of scale formation; it agrees with Hall's theory concerning growth of scale, but goes further than this theory in explaining deposition in scale at heating surfaces of substances with positive solubility slopes.

Thermal Effects of Boiler Scale, E. P. Partridge and A. H. White. Indus. and Eng. Chemistry, vol. 21, no. 9, Sept. 1929, pp. 839–844, 5 figs. New determinations of coefficient of heat conductivity of calcium sulphate boiler scales made in experimental boiler at pressure up to 150 lb. per sq. in. gage are reported; coefficient of heat conductivity measured by various investigators on 19 boiler scales; simple graphical solution of heat flow equation is given for rapid estimation of metal temperature increases caused by different rates of heat transfer, for scales of different thicknesses and heat conductivities.

High-Pressure. High-Pressure Station Reliability. Elec. World, vol. 94, no. 10, Sept. 7, 1929, p. 472. Operating experience of Milwaukee Electric Railway and Light Co. with 1300-lb. boiler and 7000-kw. turbine in station designed for 300-lb. pressure is tabulated by National Electric Light Assn.

Radical Changes Made in the Design of the Atmos Boiler, J. H. D. Blanke. Nat. Engr., vol. 33, no. 5, May 1929, pp. 207–211, 6 figs. Simplification of design of 1470-lb. pressure Atmos boiler by placing boiler tubes, which rotated in former designs, on rotor of squirrel-cage design, together with other innovations; description of boiler in recently completed French power plant.

The S.A.C.M. Boiler—Atmos (La Chaudiere S.A.C.M.-Atmos), M. Ehlinger and R. Porcherot. Société Alsacienne de Constructions Mecaniques—Bul. (Paris), vol. 7, no. 26, Apr. 1929, pp. 21–41, 27 figs. Compilation of conclusions from studies under chapters: advantages of high-steam pressures; Atmos boiler of Société Alsacienne de Constructions Mecaniques; application of rational design principles for boilers of very high pressure in this type; comparison of various types from standpoint of space requirements; article is supplemented by official test report of boiler of type described.

Locomotive. See LOCOMOTIVES, Boilers

Steam Gage, High-Pressure. Dead-Weight Gauge for the Direct Measurement of High Steam Pressures, G. S. Callendar. Engineering (Lond.), vol. 128, no. 3320, Aug. 30, 1929, p. 256. Difficulty of reading gages for recording pressures up to 4000 lb. per sq. in. and necessity for figured and careful calibration has resulted in connection of high-pressure thermometer pocket directly to dead-weight gage, arrangement of which is described.

Waste - Heat. Waste - Heat Boilers (Des chaudières de récupération), A. Capis. Arts et Métiers (Paris), vol. 82, no. 105, June 1929, pp. 224–225. Author discusses thermal conditions under which waste-heat boilers are operated; case of boilers attached to coke dry-quenching plant is considered; author points out limitations imposed by small difference between average temperature of waste gases and that of water in boiler, and suggests that use of smaller water tubes, up to point, will lead to improvements.

Water-Tube. The Largest Boilers in the World, C. W. Sengstaken. Nat. Engr., vol. 33, no. 6, June 1929, pp. 271–272, 1 fig. Three steam generating units composed of Ladd-type boiler, integral economizer, fin furnace, water screens, air preheaters, Raymond mills, and Lopulco feeding, burning and transport equipment to be installed in East River plant at New York Edison Co., are briefly described; first unit to be installed is 23 ft. 6 in. wide, 43 ft. deep, 42 ft. high with boiler heating surface 6706 sq. ft. operating pressure 425 lb.

C

CARS

Aluminum. Pennsylvania Multiple - Unit Cars With Aluminum Bodies. Ry. Age, vol. 87, no. 6, Aug. 10, 1929, pp. 373–374, 3 figs. Weight reduction of 13,200 lb. per car effected; new bodies made according to original drawings; table giving aluminum parts used on cars; table of test results for various aluminum alloys.

Dynamometer. High-Capacity Dynamometer Car for Northern Pacific Ry. Eng. News-Rec., vol. 103, no. 8, Aug. 22, 1929, pp. 304–305, 3 figs. Largest car of this type ever built is 70 ft. long, weighs 75 tons and has accommodations for crew; features recording apparatus in car; sample of record chart.

Gondola. Santa Fe Gondola Has Cast Steel Underframe. Ry. Age, vol. 87, no. 5, Aug. 3, 1929, pp. 339–340, 2 figs. Santa Fe, 70 ton capacity Gondola car is 40 ft. by 9 ft. by 5 ft. $2^1/_2$ in. inside dimensions and built by American Car and Foundry Co.; two main features are: cars are made as highly resistant as possible to combat corrosive action of sulphur and atmosphere and as cars are not interchanged accurate information regarding performance of equipment may be obtained.

Refrigerator (Carbon Dioxide). Solid Carbon Dioxide for Railway Refrigerating Cars, J. W. Martin, Jr. Ice and Refrig., vol. 77, no. 2, Aug. 1929, pp. 77–79. Paper contributed by Railroad Division and presented before annual meeting of Am. Soc. of Mech. Engrs., N. Y., previously indexed from Railroad (A.S.M.E. Trans.), Jan.-Apr. 1929.

CAST IRON

Superheating. Superheating Cast Irons Shows Varying Improvement, P. Bardenheuer and K. L. Zeyen. Iron Age, vol. 124, no. 11, Sept. 12, 1929, p. 674. Results of recent tests in which physical properties of number of cast irons were compared after each iron had been subjected to three different degrees of superheat. Translated from Mitteilung Kaiser Wilhelm Institute fuer Eisenforschung, No. 130.

COAL CARBONIZATION

Low-Temperature. A Large "K.S.G." Low-Temperature Plant at New Jersey. Iron and Coal Trades Rev. (Lond.), vol. 119, no. 3204, July 26, 1929, p. 120, 3 figs. Note on full commercial operation of plant of International Combustion Engineering Corporation, at New Brunswick, N. J.; plant is supplying minimum of 3,000,000 cu. ft. of gas of 535 B.t.u. per day; Lukens Steel Company of Coatesville, Pa., are installing large plant of 6 retorts, with capacity of 480 tons coal per hour; three K.S.G. plants are now approaching completion in Europe.

Carbonization-Plant "Lurgi" Process of Lehigh (N. D.) Briquetting Company, M. Toltz. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 7–10, 1929, 4 pp., 8 figs. First operating installation of Ferman "Lurgi" process for treating low-grade fuel is described; process is particularly adapted to North Dakota lignite; and carbonizes coal residue, with pitch by-product as binder, is pressed into merchantable briquets, which burn as smokeless fuel with high recoverable heat value.

The Illingworth Low-Temperature Carbonisation System. Engineer (Lond.), vol. 148, no. 3839, Aug. 9, 1929, pp. 150–151, 6 figs. Details are given of typical plant for carbonizing coal according to Illingworth process; vertical chambers are used with cast-iron conductors which form walls of chamber; method of charging and discharging chambers is explained; report of operations is given covering operating cost, coal analysis, screening test, and analysis of fuel.

CONDENSERS, STEAM

Cooling Condenser Water. Reducing the Cost of Cooling Water, E. Caldwell. Indus. Power, vol. 17, no. 3, Sept. 1929, pp. 63–66 and 120–138, 12 figs. Conditions under which water cooling ponds prove economical; where ground is expensive, spray ponds must be used, and for highly valuable property, cooling towers are most economical; other factors affecting choice are discussed.

CONVEYORS

Band, Design of. Capacity and Power Requirements of Conveyor Systems (Kraftbedarf und Foerderleistung bei Transport-Anlagen fuer stetige Foerderung), U. R. Ruegger. Schweizerische Bauzeitung (Zurich), vol. 94, no. 3, July 20, 1929, pp. 25–30, 6 figs. Summary of recent investigations on transporting capacity and power consumption of band conveyors; variation of friction coefficient with length, width, speed, load, and profile of band; derivation of new formula for computation of friction coefficient.

COST ACCOUNTING

[See INDUSTRIAL MANAGEMENT.]

CRANES

Design. Calculation of Luffing Cranes (Zur Berechnung von Wippkranen), K. Ruediger.

Foerdertechnik u. Frachtverkehr (Wittenberg), vol. 22, no. 13, June 21, 1929, pp. 220–224, 2 figs. It is pointed out that horizontal guiding of load is not always advantageous and that profound calculation is necessary; graphical computation is advantageous and adequate method of calculation of drive is exemplified by graphical mathematical design developments.

Jambing in Traveling Cranes and the Friction in Their Wheel Flanges (Allgemeine Darstellung ueber das Ecken der Laufkrane und ihr Spurkranzreibung), E. Ruecker. Foerdertechnik u. Frachtverkehr (Wittenberg), vol. 22, nos. 1, 2, 5, 7, and 8, Jan. 4, 18, Mar. 1, 29 and Apr. 13, 1929, pp. 1–4, 27–29, 80–82, 111–113, and 126–128, 23 figs. General presentation of conditions regarding acting forces and friction; possibility of resistance not yet quite understood; tests and testing equipment; test arrangements and results; design data derived from tests; motor devices. Bibliography.

Traveling Crab With Variable Pressure of Traversing Wheel on Girder Supported at Two Points (Laufkatze mit veraenderlichem Laufraddrucke auf einem doppelt gestuetzten Traeger), S. Rosenbaum. Foerdertechnik u. Frachtverkehr (Wittenberg), vol. 22, no. 11, May 24, 1929, pp. 183–186, 7 figs. Graphic-mathematical design developments.

CUTTING TOOLS

Heat Treatment. Cutting Tools Improved by Control of Furnace Atmosphere, J. H. G. Williams. Iron Trade Rev., vol. 85, no. 9, Aug. 29, 1929, pp. 519–520 and 561, 2 figs. Article points out why control of furnace atmosphere is important and how close attention to this detail will result in more uniform results in products.

D

DIES

Stamping, Clearances for. Die Clearances for Blanking Aluminum, E. J. Rodee. Machy. (N. Y.), vol. 36, no. 1, Sept. 1929, pp. 1–5, 11 figs. Results of laboratory tests made to determine correct die clearances to be used for blanking aluminum and aluminum alloys.

DIESEL ENGINES

Fuel Oil, Viscosity of. Viscosity of Diesel Engine Fuel Oil Under Pressure, M. D. Hersey. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 315, Sept. 1929, 8 pp., 4 figs. on supp. plates. Report prepared by Special Research Committee on Lubrication, American Society of Mechanical Engineers, presenting results of experimental tests conducted by J. N. Shore, utilizing A.S.M.E. high-pressure equipment; absolute viscosity of fuel oil determined under high hydrostatic pressure; rolling-ball type viscosimeter developed by A. E. Flowers; high-pressure equipment similar to that developed by P. W. Bridgman. Bibliography.

DUST COLLECTORS

Centrifugal. Note on Centrifugal Dust Catchers (Note sur les dépoussiéreurs centrifuges), M. Seillan. Chaleur et Industrie (Paris), vol. 10, nos. 109 and 110, May and June 1929, pp. 233–238 and 289–293, 6 figs. May: Following subjects are discussed: generalities on kinematics of dust; fundamental equation of motion of centrifuged dusts; elementary theory of simple centrifuging; elementory theory of ordinary centrifugal dust catchers. June: Author applies his mathematical studies to two particular types of centrifugal dust catchers.

E

EXECUTIVES

Duties. The Duties of a Chief Executive in a Business of Moderate Size, W. L. Batt. Mech. Eng., vol. 51, no. 9, Sept. 1929, pp. 682–684. Author visualizes functions of chief executive of modern corporation as: creation of effective operating staff; correlation of income and disbursement ordinarily through medium of so-called budget; determination of major policies and study of trend of development of business both in its relation to competition and to general conditions; paper discusses these duties of head of corporation of moderate size and attempts to evaluate their relative importance.

ELECTRIC WELDING, ARC

Atomic-Hydrogen. Atomic Hydrogen and Heavy Materials, J. T. Catlett. Welding Engr., vol. 14, no. 9, Sept. 1929, pp. 49–50, 7 figs. Applications of atomic hydrogen process to fabrications involving plate thicknesses as great as 1 in. are discussed; portable atomic-hydrogen welder manufactured by General Electric Co.; design of Corner weld explained; building-up operations successful.

F

FLOW OF WATER

Pipes. A Review of Flow in Pipes and Channels, S. J. Davies and C. M. White. Engineering (Lond.), vol. 128, no. 3316, Aug. 2, 1929, pp. 131–132, 7 figs. Laboratory investigation into roughness problem carried out by Fromm effect of shape of cross-section of pipe upon law of resistance; tested by Schiller.

FLUE-GAS ANALYSIS

New Apparatus for. A New Flue-Gas Tester (Ein kleiner Rauchgaspruefer), A. Gross. Gas- u. Wasserfach (Munich), vol. 72, no. 20, May 18, 1929, pp. 479–480, 3 figs. Apparatus consists essentially of absorption chamber, provided with special stopcock and containing slaked lime sufficient for 200 to 300 tests; loss in volume equivalent to carbon-dioxide content of gas is measured by effect of decrease in pressure on diaphragm, provided with calibrated screw which is turned until contact is made with diaphragm, lighting small lamp; apparatus is very compact and easy to use.

FURNACES

Heat-Treating. Annealing Steel Sheets in Continuous Gasfired Kilns, J. B. Nealy. Am. Soc. for Steel Treating—Trans., vol. 16, no. 3, Sept. 1929, pp. 429–434, 3 figs. Increasing use of long furnaces or kilns, which are automatic and continuous in operation, for heat treating steels is resulting in progressive betterment in their design and control; description of two modern gas-fired kiln, used in white and black annealing respectively is given; these are part of equipment of new plant of Youngstown Sheet and Tube Co. of East Chicago.

Control for Continuous Furnaces, H. W. Moss and P. S. Austen. Heat Treating and Forging, vol. 15, no. 9, Sept. 1929, pp. 1201–1204 and 1211, 6 figs. Discussion of means of close temperature regulation for mass production from continuous furnaces, including pyrometer controllers for electric furnaces and electrically operated fuel valves for gas and oil furnaces; controlling furnace zones; limits of temperature control; control for muffle-type furnace.

Pusher Type Furnaces Used in Heat Treating Forgings, W. N. Robinson. Fuels and Furnaces, vol. 7, no. 9, Sept. 1929, pp. 1421–1424 and 1428, 6 figs. Furnace installation recently completed in forge shop consists of continuous type oil-fired billet-heating furnace, gas-fired, in-and-out type forging furnace, electrically heated continuous type-hardening and tempering furnaces, and electrically heated nitriding furnace.

Metallurgical. Temperature Distribution in Combustion Furnaces, M. H. Mawhinney. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Sept. 11–13, 1929, 5 pp., 5 figs. Results of temperature measurements made in test furnace to determine temperature distribution in heating chamber for different temperatures and different methods of firing; majority of tests consisted in heating furnace to various temperatures and holding or soaking, furnace at temperature for total time of eight hours; heating characteristics of under, side, and direct firing; effects of temperature in furnace, of time, furnace dimensions, and heating materials.

Refractory Materials for. The Shape of Refractory Bricks for Suspended Roofs (Gestaltung der feuerfesten Steine fuer Haengedecken), Harraeus. Feuerfest (Leipzig), vol. 5, no. 6, June 1929, pp. 102–105, 43 figs. Author discusses factors influencing durability of refractory bricks in furnace roofs; he reproduces large numbers of shapes for suspended-roof bricks and criticizes various methods of suspension.

G

GEAR-CUTTING MACHINES

Indexing Head for. Indexing Head for Highly Accurate Spacing, F. C. Duston. Machy. (N. Y.), vol. 36, no. 1, Sept. 1929, pp. 14–16, 3 figs. Design of precision indexing head employed in making accurate gears and perforated disks required for television equipment.

GEARS

Grinding. Methods of Producing Accurate Gear Teeth Reflect Abrasive Progress, J. Rossman. Abrasive Industry, vol. 10, no. 9, Sept. 1929, pp. 24–28, 5 figs. Article illustrates and describes number of gear-grinding methods that have been patented during past few years; ground gears reduce noise, reduce friction losses in power transmission, and assure maximum life; it is claimed that it will be only question of time when hardened and ground gears will be used almost universally.

Variable Speed. The Pitter Infinitely Variable Speed Gear. Engineering (Lond.), vol. 128, no. 3318, Aug. 16, 1929, p. 201. Transmission described is primarily designed for industrial application, and consists of free wheel with sun and planet gearing.

Vibrations. Natural Frequency of Gears, R. E. Peterson. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Dec. 2–6, 1929, 7 pp., 19 figs. Natural frequency of machine parts as related to noise problem in machine operation is discussed; vibration phenomena in disks and rings described in detail; manner in which gear vibrates at its natural frequency; empirical formula is given for natural frequency of gear in terms of its dimensions and materials; data given on frequencies of rings and test blanks; effects of cutting teeth and of heat treatment on frequency.

H

HAMMERS

Steam. New Forging Machines. Eng. Progress (Berlin), vol. 10, no. 9, Sept. 1929, pp. 235–236, 3 figs. Description of heavy duty steam hammers with rams weighing from 5500 lb. to 33,000 lb.; special valve gear reduces steam consumption to about 35 to 45 lb. per effective hp.

HARDNESS

Coercive Force and Hardness. Coercive Force and Mechanical Hardness (Koerzitivkraft und mechanische Haerte), A. Kussmann and R. Scharnow. Zeit. fuer Physik (Berlin), vol. 54, no. 1–2, March 21, 1929, pp. 1–15, 6 figs. Study of relationship between coercive force (magnetic hardness) and mechanical hardness of alloys and their dependence upon structure of alloys; coercive force is shown to exhibit strong increase in case of heterogeneous mixtures where it is independent of hardness; experimental and theoretical details.

Testing. A Synopsis of the Present State of Knowledge of the Hardness and Abrasion Testing of Metals, G. A. Hankins. Mech. World, vol. 86, no. 224, Aug. 16, 1929, pp. 146–147, 2 figs. Results of investigation of direct abrasion by sand, carried out by Brinell and reviewed by Holz; discussion of diamond scratch test and comparisons of investigations by author with those of Hadfield and Main; Jertz theory of hardness; magnetic hardness test.

Methods of Hardness Testing. Am. Mach., vol. 71, no. 7, Aug. 15, 1929, p. 297, 1 fig. Monotron described is static mechanical-pressure machine employing small diamond-ball impresser point for measuring hardness of metals, minerals, glass, porcelain, brick, wood, rubber, fiber, paper, and other materials; two dials are used to take readings, one measuring pressure applied and other depth of impression under load; pressure scale reads up to 160 kg., or 352 lb., and micrometer depth gage reads in $^{1}/_{1000}$ in. and also in $^{1}/_{100}$ mm.

HEAT EXCHANGERS

Theory of. Theory of Heat Exchange in Regenerators (Ueber die Theorie des Waermeaustausches in Regeneratoren), H. Hausen. Zeit. fuer Angewandte Mathematik u. Mechanik (Berlin), vol. 9, no. 3, June 1929, pp. 173–200, 13 figs. Mathematical analysis for heat exchange between two gases of different initial temperature in regenerators and recuperators used in smelting industry.

HYDRAULIC MACHINERY

Design. Calculation and Design of Hydraulic Machines and Presses (Calcul et construction des presses et machines hydrauliques), A. Lambrette. Technique Moderne (Paris), vol. 21, no. 15, Aug. 1, 1929, pp. 463–467, 19 figs. Mathematical design data and notes on construction of cylinders and pistons of various type.

HYDROELECTRIC POWER DEVELOPMENTS

Progress in. Hydro-Electric Development Supplementing Steam, J. T. Hutchings. Engrs. and Eng., vol. 46, no. 8, Aug. 1929, pp. 181–184. Review of progress being made in hydroelectric power development in various parts of United States; present hydraulic development in Maryland, Pennsylvania, New Jersey, and New England is 1,900,000 kw. with possibilities of increasing to 7,800,000 kw.; examples of hydraulic applications that have worked out satisfactorily with small streams.

Tennessee. Calderwood Development on Little Tennessee. Power Plant Eng., vol. 33, no. 16, Aug. 15, 1929, pp. 913–915, 4 figs. Knoxville Power Co. is developing 168,000-hp. hydroelectric project on Little Tennessee River, located about six miles below North Carolina-Tennessee line; scheduled for completion in January 1930; compensated arch dam with cushion pool; concrete-lined 2200-ft. pressure tunnel; feature of project is 5600-hp. turbines.

I

ICE PLANTS

Kansas City. Ice Plant and Car Icing Station of Railway Ice Co., Kansas City, Kan. Ice and Refrig., vol. 77, no. 2, Aug. 1929, pp. 87–89, 10 figs. Illustrated article describing modern ice plant and car icing station; provision made for future expansion of all departments; hollow wall construction produces wall of monolothic concrete, resulting in efficient insulation and eliminating possibility of air infiltration.

INDUSTRIAL ECONOMICS

United States. High Wages-High Production the New Manufacturing Principle, L. P. Alford. Factory and Indus. Mgmt., vol. 78, no. 3, Sept. 1929, pp. 549–551, 1 fig. Author quotes from Report on Recent Economic Changes which shows reason for present state of prosperity in United States, progress which has been made since 1922, and favorable conditions which exist today in American industry.

INDUSTRIAL MANAGEMENT

Cost Accounting. Cost Control With Fluctuating Production, F. F. Hovey and C. E. K. Mees. Taylor Soc.—Bul., vol. 14, no. 4, Aug. 1929, pp. 160–167, 9 figs. Description of definite system used by Eastman Kodak Co. for making up cost control sheets under fluctuating production.

It Takes Us Three Days to Determine Yearly Costs, H. E. Stafford. Indus. Eng., vol. 87, no. 8, Aug. 1929, pp. 413–415, 5 figs. Illustrated description of several cost reports for making quick and accurate check-ups.

Graphic Charts. Importance of Management Graphics, T. G. Rose. Cassier's Indus. Mgmt. (Lond.), vol. 16, no. 9, Sept. 1929, pp. 301–306, 3 figs. Question of graphical management control is discussed, and various types of charts are explained; carts enable management to be in closest touch with all departments of business, and instantly show any fluctuation of circumstance that may affect policy or action.

Measurement. A Method of Measuring and Rating Management, G. G. Berger. Taylor Soc.—Bul., vol. 14, no. 4, Aug. 1929, pp. 173–179 and 187. Analysis of various phases of management resulting in setting of standards for comparison with performance.

Production Control. Systematic Control of the Small Works, S. H. Bailey. Cassier's Indus. Mgmt. (Lond.), vol. 16, no. 8, Aug. 1929, pp. 275–278, 2 figs. Method of attack for organized production control is summarized under four heads: (1) establishment of definite policies of what shall be produced; (2) establishment of definite policies of production schedules; (3) establishment of definite policies in manner in which 1 and 2 must be carried out; (4) consideration 1, 2, and 3, so that mental complications arising from positions created may be nullified also to bring required functioning of these positions within mental and physical capacities of employees.

Stores Control. Stockroom and Requisition Control System Cuts Inventory and Upkeep Cost, J. H. Hugg. Coal Age, vol. 34, no. 7, July 1929, pp. 415–418, 8 figs. Purchasing agent of coal mining company describes practice and gives report forms.

INDUSTRIAL PLANTS

Accident Prevention. Constructive Accident Prevention in the Machine Shop (Konstruktiver Unfallschutz in der mechanischen Werkstatt), B. Buxbaum. V.D.I. Zeit. (Berlin), vol. 73, no. 30, July 27, 1929, pp. 1056–1062, 15 figs. New Principles for accident prevention on metal working machinery; examples from German and American practice with regard to operation, automatic control, drive, rotating spindles; machine tools and chips, lubrication; accident prevention and increase in output.

Design. Estimating the Cost of Industrial Buildings, H. H. Fox. Arch. Forum, vol. 51, no. 3, part 2, Sept. 1929, pp. 395–398, 4 figs. Three kinds of estimates for determining cost of industrial buildings are discussed: cubic feet estimate, square feet estimate, and quantity survey; items which should be considered are foundation conditions, floor loads, and column spacing, story heights, and size and shape of building.

Planning of Industrial Buildings, M. Kahn. Arch. Forum, vol. 51, no. 3, part 1, Sept. 1929, pp. 265–272, 12 figs. Fundamental consideration of architectural features of industrial buildings and manner in which architects can be of service to designer and planner of factories; structural features of plants are also considered.

Structural Steel Design for Oberspree Cable Manufacturing Plant of the Allgemeine Elektrizitaets-Gesellschaft at Oberschoeneweide, etc. (Die Stahlkonstruktionen fuer die Neu- und Umbauten der Allgemeinen Elektrizitaets-Gesellschaft im Kabelwerk Oberspree in Berlin-Oberschoeneweide in den Jahren 1927–28), G. Mensch. Stahlbau (Berlin), vol. 2, nos. 9 and 10, May 3 and 17, 1929, pp. 101–106 and 112–117, 40 figs. Plan and structural features of copper rolling mill, of high tension cable manufacturing plant, etc.; structural details of steel columns and frames having single spans up to 40 meters wide.

Why Saddle Production With Extravagant Plant Design? C. W. Mayers. Factory and Indus. Mgmt., vol. 78, no. 3, Sept. 1929, pp. 552–554, 4 figs. Study of existing space and processes to determine definitely need of additional space; study to show comparative investment, with operating costs involved, including such questions as location of building, coordination with existing structures, and relation to possible future expansion of plant; and preparation of plans, with analysis, as design proceeds, to determine most economical type of building and comparative economy of different details of design.

Gear Works. The Crown Gear Making Works. Engineer (Lond.), vol. 148, no. 3840, Aug. 16, 1929, pp. 165–167, 4 figs. Description of Crown Works of Moss Gear Co., Ltd., Birmingham, consisting of one-story structure over 400 ft. square, housing over 1000 machine tools and 1100 workers; brief description of various machines.

Heating and Ventilation. Heating and Ventilating of Industrial Buildings, W. E. Heibel. Arch. Forum, vol. 51, no. 3, part 2, Sept. 1929, pp. 415–420, 5 figs. Modern heating systems available for manufacturer which are discussed are: fan system, direct steam system, and direct hot water system; essential parts of central heating plant; factors influencing design of ducts; use of exhaust steam; methods for air conditioning and automatic temperature control.

Lighting. Factory Lighting Layouts. Cassier's Indus. Mgmt. (Lond.), vol. 16, no. 9, Sept. 1929, pp. 311–312, 2 figs. Layout of modern factory illumination necessitates much time and thought, and plans must be prepared with view to efficiency of factory; each process of manufacture must be carefully considered, so that lighting allocated to various processes is correctly proportioned and situated with respect to each other.

Machine Shop Illumination. Elec. World, vol. 94, no. 10, Sept. 7, 1929, p. 474. Machine shop of Chandler and Price Co., Cleveland, manufacturers of printing presses and paper cutters, is lighted by means of 51 Cooper-Hewitt work-lights, which have reduced cost of current by nearly $100 per year, have eliminated former loss through theft of bulbs and have increased shop efficiency.

INTERNAL-COMBUSTION ENGINES

Detonation. The Measurement of Detonation in Internal Combustion Engines, R. O. King and H. Moss. Engineering (Lond.), vol. 128, nos. 3319 and 3320, Aug. 23 and 30, 1929, pp. 219–221, 2 figs., and 272–274, 3 figs. Aug. 23: Comparison of various methods for measuring detonation is made; methods discussed are relative fuel values in terms of standard fuel obtained by measuring detonation; relative fuel values in terms of standard fuel obtained by using variable engine factor initiate detonation; relative fuel values obtained in terms of highest useful compression ratio. Aug. 30: Determination of degree of consistency with which differences can be measured; effect of additions to fuels; comparison of results obtained by two methods.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

INDUSTRIAL TRUCKS

Gasoline. The Douglas Petrol Industrial Truck. Ry. Gaz. (Lond.), vol. 51, no. 5, Aug. 2, 1929, p. 193, 2 figs. Brief description of one-ton, three-wheeled industrial truck produced by Douglas Motors Limited; new features are that single front wheel is used for steering and driving; turning radius 6 ft. 8 in. which is also wheelbase; standard twin-cylinder air-cooled Douglas motorcycle engine.

IRON ALLOYS

Properties. Recent Research on the Physical Properties of Iron Alloys (Neuere Untersuchungen ueber die physikalischen Eigenschaften der Eisenlegierungen), A. Schulze. Giesserei-Zeitung (Berlin), vol. 26, nos. 14 and 15, July 15 and Aug. 1, 1929, pp. 389–398 and 428–434, 37 figs. Review of investigations of most important physical properties of iron-carbon, iron-nickel, iron-silicon, iron-aluminum, iron-manganese, iron-cobalt, iron-chromium, and stainless steels; influence of different alloying elements on behavior of iron; comparison of properties of iron alloys.

L

LATHES

Electric-Drive. Magnetic Control Simplifies Individual Lathe Drive, H. H. Watson. Elec. World, vol. 94, no. 9, Aug. 31, 1929, pp. 434–435, 1 fig. Front and back view of Pratt and Whitney 16-in. model B. lathe is shown with motor and control equipment installed in one of buildings in Schenectady Works of General Electric Co., which is devoted to manufacture of industrial control devices.

LIQUIDS

Evaporation. The Secometer, a Device for Measuring the Rate of Evaporation of Liquids, G. L. Clark. Australasian Inst. Min. and Met.—Proc. (Melbourne), no. 71, Sept. 30, 1928, pp. 81–85, 2 figs. Instrument consists essentially of thermometer with sliding scale divided by three pointers into two equal parts; instrument is calibrated so that amount of heat required per unit area of bulb to raise meniscus 1 deg. is known; tested against rate of drying of wet leather; results compared with mean of successive readings of secometer taken in vicinity of test squares during dry period; commercial use in drying of leather, porcelain, timber, and for substances such as fruit.

LOCOMOTIVES

Boilers, Corrosion Prevention in. Gunderson Process for Eliminating Boiler Corrosion. Boiler Maker, vol. 29, no. 8, Aug. 1929, pp. 217–220 and 239, 5 figs. 75 locomotive boilers of Chicago and Alton Railroad are equipped with Gunderson process which consists of introducing compound of arsenic into boiler in 1-lb. tubes through washout holes; electric current obtained from headlight generator and from storage battery is passed through water to interior metal surfaces of boiler; treatment of feedwater; analysis of raw water supplies; shopping records with and without electrode equipment; explanation of process.

Design. Recent Trends in Design of American Locomotives (Neuere Bestrebungen im amerikanischen Lokomotivbau), E. Metzeltin. V.D.I. Zeit. (Berlin), vol. 73, no. 31, Aug. 3, 1929, pp. 1087–1091, 15 figs. Causes for increase in size; improvement in economy of boilers and furnace equipment; tube forms, draft, draft control, and preheaters; cast steel frames and cylinders of one piece and other improvements are discussed.

Steam Locomotive Design; Data and Formulae. Locomotive (Lond.), vol. 35, no. 444, Aug. 15, 1929, pp. 254–256. Consideration of following climatic conditions; water; fuel; civil engineering limitations; rail gage; loading gage; gradients and curves; permanent way; mechanical engineering restrictions; conditions imposed by traffic department; legal stipulations.

Diesel. Automatic Transmission Employed in Diesel-Engined Locomotive. Automotive Industries, vol. 61, no. 7, Aug. 17, 1929, pp. 231–232, 2 figs. Brief description of 30 hp. locomotive with Robertson automatic variable-speed transmission gear, details of which are given.

Economy of Diesel Locomotives in Main Line Operation (Die Wirtschaftlichkeit der Diesel-Lokomotive im Vollbahnbetrieb), H. Strasser Organ fuer die Fortschritte des Eisenbahnwesens (Munich), vol. 84, nos. 8 and 9, Apr. 15 and May 1, 1929, pp. 123–131 and 143–149, 13 figs., 8 diagrams. Classification of Diesel locomotives; detailed analysis of costs of operation; fuel consumption by superheat and Diesel electric locomotives; data on operation of Diesel electric and Diesel gear locomotives in Russia, and of Diesel compressed air locomotives in Germany; comparison of costs indicates superiority of Diesel locomotives.

Passenger Diesel Locomotive 2-4-2 for the Russian Profile (Personenzug-Diesellokomotive 2-4-2 fuer das russiche Profil), G. Mangold Glasers Annalen (Berlin), vol. 105, no. 1, July 1, 1929, pp. 1–5, 10 figs. Engine is equipped with two Diesel motors one of which is directly, other indirectly coupled to axle system; design details and data regarding calculation of tractive effort; efficiency and weight of locomotive designed by author, are given.

Electric. Electric Locomotives Availability With Special Reference to Butte, Anaconda and Pacific Ry., F. W. Bellinger. Gen. Elec. Rev., vol. 32, no. 9, Sept. 1929, pp. 462–465, 3 figs. Based on experience, it is shown that electric locomotives can be kept in service greater percentage of time than can steam locomotives, as availability figure still is about 98.5 per cent after 16 years of service; though operating conditions are severe locomotives have not required general overhauling; elaborate inspection and shop facilities have been unavailable; detailed data of operation, computation of availability, road profile, etc., are given.

Forgings for. Locomotive Forgings, L. H. Fry. Am. Mach., vol. 71, no. 10, Sept. 5, 1929, pp. 411–412. Factors to be considered in producing locomotive forgings are taken up; choosing proper methods for making steel; chemical composition; securing correct ingot structure; five types of steel commonly used for locomotive forgings. Abstract of paper presented before Am. Soc. for Steel Treating.

4-8-4. D. and R. G. W. Buys Ten 4-8-4 Type Locomotives. Ry. Age, vol. 87, no. 8, Aug. 24, 1929, pp. 457–458, 3 figs. Cylinders are 27 in. by 30 in.; drivers 70 in.; boiler pressure 240 lb.; total weight 209 tons; total wheelbase 44 ft. 5 in.; tractive force 63,700 lb.; cross section and elevation drawings.

4-8-4 Type Locomotive for the Canadian National. Ry. Age, vol. 87, no. 7, Aug. 17, 1929, pp. 414–416, 4 figs. Locomotive described is designed for use in either passenger or fast freight service; cylinders $25^1/_2$ in. by 30 in.; drivers 73 in.; boiler pressure 250 lb.; total weight 383,000 lb.; wheel-base 3 ft. 10 in.; tractive effort 56,800 lb. See Engineering Index, 1928, p. 1086.

4-8-4 Type Locomotives for the Lackawanna, S. S. Riegel. Ry. Mech. Engr., vol. 103, no. 8, Aug. 1929, pp. 500–503, 7 figs. Construction of cylinder boiler-fit permits locating steam pipes, completely within smokebox; new locomotives known as Pocomo type, have 28 in. by 32 in. cylinders, 70 in. drivers and boiler operated at 235 lb. pressure; maximum tractive force 71,600 lb.; total weight of engine 418,000 lb.; cylinder construction; special equipment.

High-Pressure. Delaware and Hudson Locomotive. Ry. Jl., vol. 35, no. 8, Aug. 1929, pp. 22–23, 3 figs. Description of 4-6-2 type designed fast passenger service; cylinder 22 x 28 in.; tractive effort 41,600 lb.; total weight, loaded 283,300 lb.; wheelbase, 34 ft. 10 in.

M

MACHINE DESIGN

Wood in Machine Construction. Viewpoints of Design in the Application of Wood in Machine Construction (Konstruktive Gesichtspunkte bei der Verwendung von Holz im Maschinenbau), O. Steinitz. Maschinen-Konstrukteur (Berlin), vol. 62, no. 16, Aug. 15, 1929, pp. 362–365, 2 figs. Mechanical properties and strength of various kinds of wood are discussed from standpoint of increased importance of wood as used in recent machine construction.

MACHINE SHOPS

[See INDUSTRIAL PLANTS.]

MACHINE TOOLS

Electric Drive. High-Frequency Motors for Portable Tools, C. B. Coates. Am. Mach., vol. 71, no. 11, Sept. 12, 1929, p. 450. Development of portable electric drills briefly outlined; advantages of induction-motor tool and reduction of weight obtained by increasing frequency; factors governing selection of standard frequency for those tools. Abstract of paper presented before Am. Inst. Elec. Engrs.

Twin-Unit Machines. Twin-Unit Machines for Multiple Production, F. H. Mayoh. Am Mach., vol. 71, no. 7, Aug. 15, 1929, pp. 289–292, 10 figs. Examples are given of planers and millers with multiple spindles or two tables for operating on more than one piece, or several parts of one piece in sequence.

METALS

Fatigue of. High-Frequency Fatigue, C. F. Jenkin and G. D. Lehmann. Roy. Soc.—Proc. (Lond.), vol. 125, no. A796, Aug. 1, 1929, pp. 83–117 and (discussion) 117–119, 24 figs. Researches to determine effect of frequency of alternation of stress on fatigue limits of various metals were carried out at Engineering Laboratories, Oxford, tested rolled, normalized and hardened steel, rolled aluminum, annealed copper and normalized armco iron; fluctuations of air pressure acting directly on specimen were used to make them vibrate; increase of fatigue limit up to 60 per cent recorded.

The Correlation of Fatigue and Overstress, J. H. Smith and F. H. Armstrong. Iron and Steel Inst.—Advance Paper (Lond.), no. 10, Sept. 1929, 29 pp., 26 figs. Brief summary of recent methods used in attempt to give satisfactory practical explanation of phenomenon of fatigue of metals; strain method was used in tests to determine variation of fatigue limits resulting from overstress; yield ranges of steel which has failed in practice were investigated; description of testing machine; test methods and results.

The Fatigue Testing of Sheet Metals, J. R. Townsend and C. H. Greenwall. Metal Stampings, vol. 2, no. 8, Aug. 1929, pp. 599–600. Description of testing procedure; results of cold work on physical properties of non-ferrous metals as indicated by fatigue tests.

The Influence of Oxygen on Corrosion Fatigue, A. M. Binnie. Engineering (Lond.), vol. 128, no. 3318, Aug. 16, 1929, p. 190, 1 fig. Experiments described were carried out in Engineering Laboratory at Oxford to determine to what extent reduction of fatigue limit of certain steels by corrosion is due to pressure of oxygen in surrounding atmosphere; specimens used were cut from same bar and were tested in Woehler rotating-cantilever machine at 2000 r.p.m.; fatigue limit in air, at ten million reversals, is 17.0 tons per sq. in., this being calculated from nominal bending stress.

Machinability. Machinability of Metals, O. W. Boston. Am. Mach., vol. 71, no. 10, Sept. 5, 1929, p. 415. Results of various machinability tests made at University of Michigan are shown in tables for steel and non-ferrous metals; data were determined by measuring force on planer tool, torque and thrust of $^3/_4$-in. diameter drill, penetration in inches per 100 r.p.m. per minute, of $^1/_4$-in. diameter drill, and energy in foot-pounds required to remove chip by milling. Abstract of paper presented before Am. Soc. for Steel Treating.

Testing. Press Working and Forming of Metals, E. V. Crane. Metal Stampings, vol. 2, no. 8, Aug. 1929, pp. 585–590, 5 figs. Discussion of methods of determining rate of strain hardening of metals; effect of direction of loading on nature of deformation.

Testing of Metals and Alloys at High Temperatures for Compression and Drawing (Les essais à chaud des metaux et alliages par compression et par filage), A. Portevin and F. Le Chatelier. Academie des Sciences—Comptes Rendus (Paris), no. 5, July 29, 1929, pp. 248–250. Discussion of experimental data and derivation of empirical formula.

MILLING MACHINES

Dividing Head. Dividing Head and Its Importance for the Repair Work Shop (Der Teilkopf und seine Bedeutung fuer die Reparaturwerkstatt), F. H. Huth-Illmenau. Maschinen-Konstrukteur (Berlin), vol. 62, no. 16, Aug. 15, 1929, pp. 370–373, 4 figs. Fundamental construction details and uses of device are outlined; in order to show its importance in workshop and fabrication; milling equipment of Wanderer Works of Schoenau near Chemnitz.

N

NITRIDATION

Equipment for. Hardening Steel in Ammonia Gas. Iron Trade Rev., vol. 85, no. 10, Sept. 5, 1929, pp. 597–598, 1 fig. Description of nitriding equipment and operations employed by American Metal Treatment Co., Elizabeth, N. J., subsidiary of American Gas Furnace Co.; experiments conducted by American Gas Furnace Co., indicate better results with relatively low gas concentration and greater time element.

O

OIL ENGINES

Fuel Economy. Proposes Better Expansion for Fuel Efficiency, E. J. Kates. Oil Engine Power, vol. 7, no. 9, Sept. 1929, pp. 518–519. Statement of fuel economy in terms of output per unit of fuel volume is presented as superior to more common method quoting pounds of fuel per b.hp-hr., as engine performance and fuel cost are more directly related to volume.

OPEN-HEARTH FURNACE

Practice. Heat Economy and Heat Engineering in Open-Hearth Practice (Waermewirtschaft und Waermetechnik im Siemens-Martin Betrieb), A. Nahoczky. Feuerungstechnik (Leipzig), vol. 17, no. 13–14, July 15, 1929, pp. 145–149, 8 figs. Calculations and curves pertaining to cooling surface and heat losses; average heat quantities per kg. ton and per hour; heat distribution in per cents; efficiency coefficient and dimensioning of furnaces; temperatures in operating room; exhaust gas temperatures as function of changes in gas and efficiency; influence of tar and water contents of gas.

P

PIPE JOINTS

Flanged, Design of. The Design of Flanged Pipe Joints, S. Crocker. Heat., Piping and Air Conditioning, vol. 1, no. 4, Aug. 1929, pp. 293–300, 10 figs. Brief description of some common types of flanged joints and design data; relation of bolting to internal pressure; bolt tension required to compress gasket; dimensions of box wrenches for standard nuts; stress data; method of computing wrench effort from bolt tension.

PLANERS

Metal-Working. Large Combination Planing and Milling Machine, S. Weil. Eng. Progress (Berlin), vol. 10, no. 9, Sept. 1929, pp. 244–246, 3 figs. Machine described has capacity for milling and planing pieces up to length $26^1/_2$ ft., width of $13^1/_2$ ft. and height of 12 ft.; provision for tool carriers consists of two planer heads and two miller heads on cross rail and planer head on right-hand housing, while left-hand housing is so constructed as also to permit attachment of tool head when desired.

PRESSURE VESSELS

Testing. Fatigue Tests on Drums and Shells, H. F. Moore. Iron Age, vol. 124, no. 10, Sept. 5, 1929, pp. 607–611, 9 figs. Description of apparatus and methods of test developed by laboratory force of Barberton plant of Babcock and Wilcox Co.; results of fatigue tests of boiler drums and shells; riveted manganese-steel drum failed in head; riveted carbon-steel drum did not fail; welded and forged shells failed at tapped hole.

PULVERIZED COAL

Combustion of. The Thermodynamics of the Combustion of Powdered Coal, P. Rosin. Inst. of Fuel—Jl. (Lond.), vol. 2, no. 8, July 1929, pp. 368–379 and (discussion), pp. 379–380, 7 figs. Paper deals with liberation of heat in combustion space and features on which it depends; relations between waste gas volume and heat volume; dependence of rate of heat liberation on excess of air; influence of turbulence on heat liberation; maximum possible rate of heat liberation. Reprint of paper read before Second International Conference on Bituminous Coal.

PUMPS

Oil, Electric Drive for. Electric Motors in Main Oil Pipe Line Pumping, G. R. Prout. Gen. Elec. Rev., vol. 32, no. 9, Sept. 1929, pp. 490–496, 11 figs. Over 115,000 hp. in motors driving main oil-pipe line pumps in Texas, Oklahoma, and Arkansas; this has nearly all been installed since January 1, 1927; of 115,000 hp. in motors driving main line pumps, about 80,000 hp. is direct connected to centrifu-

gal pumps; remaining 35,000 hp. is driving reciprocating pumps; from this experience economies of various types of drive are determined; analysis of motor-driven centrifugal and reciprocating pumps, centrifugal pump operation, and automatic control are described.

R

RAILWAY SIGNALS

Chicago and Alton. The Chicago and Alton Installs Mechanical Plant. Ry. Signaling, vol. 22, no. 8, Aug. 1929, pp. 295–296, 4 figs. Installation of 24-lever mechanical interlocking plant at crossing of Illinois Central at Delavar, Ill., eliminates train stops; unique electric locking system.

Erie. Erie Equips Complete Division With Signals and Interlockers. Ry. Signaling, vol. 22, no. 9, Sept. 1929, pp. 317–322, 15 figs. Color-light train-order signals and remote control of absolute signals are features of installation; Meadville division from Salamancia, N. Y., Meadville, Pa., 106 mi. equipped with color-light automatic-block signals, including four remote-control power-switch layouts, two new interlockings and the reconstruction of several old plants.

Great Northern Ry. The Great Northern Reconstructs Automatic Signaling in the New Cascade Tunnel. Ry. Signaling, vol. 22, no. 8, Aug. 1929, pp. 281–284, 6 figs. Rearrangement of automatic signal system from Wenatchee, Wash., to Skykomish including new tunnel through Cascade Mountains; changes track circuits from d-c. to a-c.; scheme of signaling in tunnel; d-c. line relays outside of tunnel.

RAILWAY TRAIN CONTROL

Automatic. Lackawanna Modernizes Signal System for Automatic Train Control, J. E. Saunders. Ry. Signaling, vol. 22, no. 8, Aug. 1929, pp. 290–294, 8 figs. Change from semaphore to color-light signals shows net annual saving of over $2000 for 57 mile section of double track; two-speed continuous train control; power supply and transmission; construction details, cost comparison.

Light-Sensitive Bridge. Optical Features of German Train Control Reflect Ingenuity. Ry. Signaling, vol. 22, no. 8, Aug. 1929, pp. 299–302, 8 figs. System uses light source, reflector, mirror, and selenium cell to control trains automatically; illustrated detail description of intermittent principle employed; advantages of optical control.

REFRIGERATION

Evaporating Systems. A New Evaporating Unit. Cold Storage (Lond.), vol. 32, no. 377, Aug. 15, 1929, pp. 251 and 255, 3 figs. New multifeed evaporating system has been designed by G. Flieger; illustrated description of working cycle; system adapts itself readily to any kind of pipe coil evaporator.

ROCKET PROPULSION

Theory. Proof for the Agreement Between the Rocket Theory and the Law of Energy (Beweis der Uebereinstimmung der vorliegenden Raketen-theorie mit dem Energiegesetz), G. Pirquet. Maschinen-Konstrukteur (Berlin), vol. 62, no. 14, July 15, 1929, pp. 321–324. Fundamental principles of rocket theory are given followed by reply and criticism of K. Baetz on article of Oberth and author.

ROLLING MILLS

Strip Mills. Continuous Mill Rolls Strips at High Speed, G. S. Warren. Rolling Mill Jl., vol. 3, no. 8, Aug. 1929, pp. 359–362, 4 figs. Wide range of strip sizes hot rolled at speeds up to 2400 ft. per min. uses variable-speed motors for both roughing and finishing mills, stands of latter being individually driven; microphone and loud speaker used for transmitting instruction to control room.

ROPE DRIVE

Multiple-Pulley. Multiple-Pulley Drive, Especially With Compensated Tension, and Grip-Check Pulleys (Mehrscheibenantriebe, besonders mit Spannungsausgleich, und Klemmbackenscheiben), O. Ohnesorbe. Foerdertechnik u. Frachtverkehr (Wittenberg), vol. 22, nos. 9 and 10, Apr. 26 and May 10, 1929, pp. 143–147 and 165–169, 9 figs. Behavior of ropes with regard to tension, bending, and crushing stresses; prevention of slip, resulting from simultaneous stretch in case of multiple rope pulleys and advantages; disadvantage of carrying ropes through grip checks.

S

SCREW-CUTTING MACHINES

Full Automatic. Special Automatic Machine for Thread Cutting (Sonderautomat fuer Gewindearbeiten), O. Lich. Maschinen-Konstrukteur (Berlin), vol. 62, no. 14, July 15, 1929, pp. 315–320, 13 figs. Full automatic machine for purpose of cutting short threaded ends in great quantities, is described; performance data and calculation for change of transmission gears are given.

SEAPLANES

Design. Engineering Details in the Constructive Development of Rohrbach Flying Boats (Technische Besonderheiten in der baulichen Entwicklung der Rohrbach-Flugboote), G. Mathias and A. Holzapfel. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 20, no. 13, July 15, 1929, pp. 334–338, 10 figs. Starting tests with giant flying boat Rohrbach Romar with 19 tons take-off weight and effective load of $2^1/_2$ ton carried up to 2000 m. elevation together with successful seaworthiness tests are basis of article discussing structure, boat body, wing top floats, motor equipment, rolling, starting, and flying characteristics.

Monoplane (Dornier). The 100 Passenger Dornier DO. X, W. R. Hanawalt. Aero Digest, vol. 15, no. 2, Aug. 1929, pp. 114 and 116, 3 figs. Description of DO. X 100-passenger Dornier flying boat powered by twelve 500-hp. Jupiter engines; semi-cantilever high-wing monoplane with 157-ft. wing span; wing covering not permanently attached to spars and ribs, but consists of stiff self-contained metal plates easily detachable; hull divided into three decks; engines mounted above plane in tandem pairs; top speed 150 m.p.h.; results of tests.

SHEET-METAL WORKING

Drawing Sheets From Blanks. The Drawing of Cylindrical Sheets From Flat Round Blanks, E. V. Crane. Metal Stampings, vol. 2, no. 9, Sept. 1929, pp. 661–669, 9 figs. Discussion of movements and calculation of stresses in sheets caused by deep drawing operations; determination of maximum reduction, drawing pressures; applications of blank holders for round blanks.

STEAM CONDENSERS

Surface. The Invention of the Marine Surface Condenser. Engineering (Lond.), vol. 128, no. 3321, Sept. 6, 1929, pp. 284–285. Few particulars of invention, introduction, abandonment and reintroduction of this type of condenser to restate claims of Samuel Hall as pioneer of this important unit in power plants.

STEAM ENGINES

Exhaust. Regulating Gear for Exhaust Pressure and Extraction Steam Turbines and Engines. Eng. and Boiler House Rev., vol. 42 and 43, no. 12 and 1, June and July 1929, pp. 685–686 and 56–59, 7 figs. Explanation of diagrammatic arrangement of compound engine working with steam extraction; pressure transmitter, oil operated steam pressure regulator and Drayton double-relay pressure regulator described.

STEAM HEATING

Unit Heaters. Heat and Air Volume Output of Unit Heaters, L. S. O'Bannon. Heat., Piping, and Air Conditioning, vol. 1, no. 4, Aug. 1929, pp. 323–328, 7 figs. Results of series of 16 tests made on three unit heaters by University of Kentucky in cooperation with Research Laboratory of Am. Soc. of Heat. and Vent. Engrs.; two methods in common use for measuring air volume output by Pitot tube and by condensate-temperature rise method were used and advantages and disadvantages of each determined.

STEAM PIPE LINES

Design. Piping for Steam Power Service, M. W. Ehrlich. Heat., Piping, and Air Conditioning, vol. 1, no. 5, Sept. 1929, pp. 392–393, 1 fig. Development of chart for determining steam flow and pipe sizes for both saturated and superheated steam and examples of applications.

STEAM-ELECTRIC POWER PLANTS

Cahokia. New 75,000 kw. Cahokia Unit. Power Plant Eng., vol. 33, no. 17, Sept. 1, 1929, pp. 947–951, 11 figs. Novel condenser arrangement with two expansion joints being used, one below and one above shell; generator and turbine with steam consumption of latter; illustrated description of boilers.

Detroit. Half a Million Gallons of Water Each Minute Will Flow to the Ford Rouge Plant. Power, vol. 70, no. 12, Sept. 17, 1929, pp. 449, 1 fig. Outline of system to supply condensing water for two new 110,000-kw. turbine generators and additional plant service; water to be drawn from Detroit River $2^1/_4$ mi. away through gravity tunnel 15 ft. in diam.

Philo, Ohio. New 165,000 kw. Unit no. 3 at Philo in Service. Power Plant Eng., vol. 33, no. 17, Sept. 1, 1929, pp. 965–967, 2 figs. Original ultimate station capacity of 240,000 kw. completed by new unit; has one high-pressure and two low-pressure elements; cross-section view of new and old boilers; list of principal equipment for unit no. 3.

165,000 Kw. Unit Goes Into Operation at Philo, Ohio, L. S. Leavitt. Elec. Light and Power, vol. 7, no. 9, Sept. 1929, pp. 42–45, 5 figs. Station built by American Gas and Electric Co., is described; initial equipment consisted of two 40,000-kw. single-chamber turbine generators and six B. and W. cross-drum boiler with 2 reheat boilers, condensers, air heaters, and ash removal equipment; generators are General Electric three-phase 60-cycle, 95 per cent power factor, 11,000-volt machines; were originally rated at 35,000 kw. but by increasing steam pressure at throttle from 535 to 550 lb. unit could deliver in excess of 40,000 kw.

Mt. Holly, N. C. Engineering Requirements That Determined the Design of the Riverbend Power Plant, D. Nabow. Power, vol. 70, no. 10, Sept. 3, 1929, pp. 363–369, 5 figs. Latest plant constructed by Duke Power Co. has installed two 55,000 kw. units; ultimate capacity of plant to be 450,000 kva.; description of plant equipment; heat-balance diagram of plant; plan and elevation layouts; list of principal equipment.

STEAM POWER PLANTS

Economy. New Developments in Steam Economy (Neues auf dem Gebiete der Dampfwirtschaft die maschinen), E. A. Kraft. Sparwirtschaft (Vienna), no. 5, May 1929, pp. 328–333, 10 figs. Improvement obtained in thermal and machine efficiency through coupling of power and industrial plants; application of experience gained; condensation machine; engines for coupled power plants and industrial plants; high-pressure problems.

England. World's Largest H. P. Industrial Boiler Plant. Elec. Times (Lond.), vol. 76, no. 1973, Aug. 15, 1929, p. 231, 2 figs. Boiler installation of eight "Lopulco" forged steel drums; boilers at super-power station of Synthetic Ammonia and Nitrates Co. of Billingham-on-Tees is described; boilers are to operate at 800 sq. in. pressure with normal evaporation of 260,000 lb. of water per hour each; cost of installation 800,000 pounds sterling.

High - Pressure, Mannheim, Germany. The 1500-Lb. Pressure Steam Plant at Mannheim Power Station, F. Marguerre. Engineering (Lond.), vol. 128, nos. 3319 and 3320, Aug. 23 and 30, 1929, pp. 225–228 and 252–255, 9 figs. Aug. 23: Detail plans and elevation are shown for high-pressure plant installed in connection with existing plant which consisted of three single-cylinder 12,500-kw. turbine and three-cylinder 20,000-kw. turbines designed for steam pressure of 255 lb. per sq. in.; reasons for adoption of high pressure are given. Aug. 30: Type of material selected for drums of boilers and investigation of stresses; results of special study of expansion of tubes; general design of boilers; type of superheater and economizer; main features of lines, fittings, packings, flanges, valves, etc.

Industrial, Design of. Process Requirements Dictate Power Plant Design. Power, vol. 70, no. 9, Aug. 27, 1929, pp. 324–331, 12 figs. Although boiler pressure of 450 lb. are usual in industrial power plants, new plant of Industrial Rayon Corp. at Covington, Va., finds that 250 lb. gives most economical heat balance; locality and processes of manufacture are important considerations of plant design; illustrated description of equipment; plan of power house and list of equipment.

Kearny, N. J. Construction of Power Plant Near Newark (Der Bau des Kraftwerks Kearny bei Newark), H. Griesel. V.D.I. Zeit. (Berlin), vol. 73, no. 32, Aug. 10, 1929, pp. 1119–1123, 9 figs. Plant has to meet rise in demand of industrial and residential energy in this New Jersey district resulting from opening of Holland Tunnel; construction of plant is described and brief notes on mechanical and electric equipment are given.

Management. Accurate Repair Records Essential to Efficient Maintenance Methods, W. N. Polakov. Power, vol. 70, no. 8, Aug. 20, 1929, pp. 290–291, 2 figs. Maintenance records if accurate and complete help to select most suitable materials, parts, and supplies; study and intelligent use of records tend to make operation safe, uninterrupted, more comfortable and more

economical; repair record; example of instructions for annual inspection of turbine generator.

Operation. Power Station Practice in Great Britain, D. Brownlie. Combustion, vol. 1, no. 2, Aug. 1929, pp. 34–38, 5 figs. General changeover from generation of electricity by multitude of small stations to relatively limited number of large and efficient power plants, and also rapid growth of overhead high tension transmission lines; low amount of electricity consumed per capita; general trend toward super-power system; changes taking place within plants.

Peak Loads. Flue Gases Heat Standby Boilers, V. F. Estcourt. Elec. World, vol. 94, no. 8, Aug. 24, 1929, pp. 371–372, 2 figs. Arrangement of system used by Pacific Gas and Electric Co. whereby one boiler under fire keeps five standby boilers hot by use of flue gas; flue gases are bled from boiler in regular operation and discharged by fan through heavily insulated duct leading to furnaces of boilers; duct is along front of boilers above oil burners; saving of three barrels of oil per day per boiler results.

Power and Process. Estimating Byproduct Power, R. J. Gaudy. Elec. World, vol. 94, no. 10, Sept. 7, 1929, pp. 472–473, 1 fig. Need for short and easily applied method to arrive at preliminary estimate of power possibility; curves permit approximation from figures on steam-pressure drop; curves showing power available from steam-pressure reductions for process use.

Byproduct Power From Process Steam, J. F. Ferguson. Power, vol. 70, no. 13, Sept. 24, 1929, pp. 480–482, 1 fig. General discussion of generation of by-product steam; it is predicted that reciprocating machine as prime-mover and boiler-feed pump will become popular type of unit for industrial plants; chart giving power available from process and heating steam.

STEAM TURBINES

Progress. Recent Progress in Steam-Turbine Plant, C. A. Parsons. Engineering (Lond.), vol. 128, no. 3318, Aug. 16, 1929, pp. 213–216, 7 figs. Historical notes in development of steam turbine and use of turbo-generators for power generation in England and South Africa; increase in fuel economy and output per unit; improvements in surface condenser design; progress in high-speed alternator construction; improvements in steel for forgings; application to marine propulsion.

Stresses. Internal Stresses and Heat Stresses and Their Relation to Steam Turbine Construction, E. Honegger. Brown Boveri Rev. (Baden), vol. 16, no. 9, Sept. 1929, pp. 243–253, 14 figs. Kinds of internal and heat stresses are defined; internal stresses and heat stresses in spheres and cylinders are given; practical applications of theoretical formulas.

Testing. Efficiency Effect of Erosion of Blades on a Radial Flow Turbine, B. F. Treat. Am. Soc. Naval Engrs.—Jl., vol. 41, no. 3, Aug. 1929, pp. 444–450, 5 figs. Article describes and gives results of test made at U. S. Naval Engineering Experiment Station on turbine to determine steam consumption with progressive simulated blade erosion; turbine tested was 24 in. diameter wheel, designed for normal operation at 72 b.hp., 250 lb. per sq. in. steam pressure, and 820 r.p.m. speed.

STEEL

Boiler. Boiler Steels at High Temperatures. Engineering (Lond.), vol. 128, no. 3316, Aug. 2, 1929, pp. 156–157, 6 figs. Report of tensile and creep tests of 0.17 per cent carbon steel normalized and 0.10 per cent cold drawn with intermediate anneal followed by final anneal for six hours at 650 deg. fahr.; both test pieces were of steel for boiler and superheater tubes and drums.

Carburized, Testing. A New Method of Testing the Depth of Case on Carburized Steel, F. A. Firestone and E. J. Abbott. Metals and Alloys, vol. 1, no. 1, July 1929, p. 18, 1 fig. Article described apparatus which was devised by authors in laboratories of Department of Engineering Research of University of Michigan for Timken Roller Bearing Co., this apparatus has not been developed beyond experimental form; but it offers considerable possibilities for control and testing work on case-carburized products.

Hardening. Salt Baths for the Hardening of High Speed Steel, J. Kjerrman. Am. Soc. for Steel Treating—Trans., vol. 16, no. 3, Sept. 1929, pp. 393–404, 2 figs. Results of series of experiments on salt baths containers used for heating high-speed steel for hardening; decarburization of metal being heated is one of difficulties encountered; effect of crucible material, salt used and combinations of two are reported; chamotte crucible as container for barium chloride to which sufficient amount of ferrosilicon was added, could be used.

The Hardening of Superhardened Steel by Magnetism, E. G. Herbert. Iron and Steel Inst.—Advance Paper (Lond.), no. 5, Sept. 1929, 17 pp. Investigation of phenomena taking place in Cloudburst process with view to their practical application in increasing hardness of work-hardened layer; endeavors to discover something of physical basis of phenomena and their relation to low-temperature changes in metal; low temperature annealing of superhardened steel; magnetic treatment arrived at by inductive reasoning from increased hardening of previously work-hardened metals as result of aging or P-3 anneal; lattice resonance hypothesis. Bibliography.

Heat-Resisting. Heat-Proof Steels (Warmfeste Stahle), E. Houdremont and V. Ehmeke. Kruppsche Monatshefte (Essen), vol. 10, July 1929, pp. 79–94, 16 figs. Method for determination of heat-resisting properties; curve showing heat resistance relative to time; heat resistance of steels used in manufacturing valves for combustion engines; behavior of steels in temperature ranges below 650 deg., stretch limit and comparative heat-resistance curves; tabulation of test results.

Heat Treatment. A Study of Burning and Overheating of Steel, W. E. Jominy. Am. Soc. for Steel Treating—Trans., vol. 16, no. 3, Sept. 1929, pp. 372–391, 17 figs. This section covers particularly forging of steels, after heating in various atmospheres, to determine limiting temperatures in forging; these experiments were conducted on series of plain carbon and alloy steels; tests are summarized in table showing temperatures at which various steels investigated will burn if forged immediately after heating in direct-fired gas furnace when using excess of gas and air.

STEEL CASTINGS

Foundry Practice. Producing Steel Castings in the Modern Foundry, C. W. Veach. Foundry, vol. 57, no. 16, Aug. 15, 1929, pp. 708–710 and 721. After heat is melted, metal and slag conditions must be observed carefully so that refining may be carried out rapidly without undue exposure of metal to flame; author describes addition of spiegel-eisen and ferrosilicon and their action on bath; he also described practice in vogue 20 years ago in operating furnace, and compares it with modern operation.

Reducing Cost of. Lowers Cost of Steel Castings by Improved Materials Handling, H. R. Simonds. Iron Trade Rev., vol. 85, no. 10, Sept. 5, 1929, pp. 589–593, 6 figs. See also Foundry, vol. 57, no. 17, Sept. 1, 1929, pp. 726–732, 8 figs. Description of reorganized steel foundry operated by Easton Steel Castings Co., Newark, N. J.; rearranging of plant and installation of modern equipment converted uneconomical foundry into efficient unit; coreroom equipment; sand moisture controlled automatically; roller conveyors employed; only electric steel made and only one expert melter required.

Temperature Effect. Mechanical Properties of Cast Steel at High Temperatures (Mechanische Eigenschaften von Stahlguss bei erhoehten Temperaturen), F. Koerber and A. Pomp. Zeit. des Bayerischen Revisions-Vereins (Munich), vol. 33, no. 13 and 14, July 15 and 31, 1929, pp. 195–196 and 211–212, 4 figs. Results of tests carried out at temperatures up to 500 deg. cent. on 12 different cast steels. Abstract from Mitteilungen des Kaiser-Wilhelm Inst. fuer Eisen-forschung.

STOKERS

Traveling-Grate. Modern Traveling Grate Stokers. Eng. and Boiler House Rev. (Lond.), vol. 43, no. 2, Aug. 1929, pp. 80 and 82, 1 fig. Description of two underfeed stokers being constructed for Deptford East Power plant, which are largest in world; each is 31 ft. wide with 700 sq. ft. of grate area for boilers of 200,000 lb. normal evaporation per hr.

Underfeed. Underfeed Stokers Burning Indiana Coal Show Large Saving. Power, vol. 70, no. 11, Sept. 10, 1929, pp. 406–409, 6 figs. Earlier attempts to burn this coal in pulverized form at Noblesville plant of Ball Brothers Co. proved unsatisfactory, partly because of high moisture content; revamping of boiler plant, with installation of modern large boiler units, including economizer, air preheater and water-cooled furnace walls and 8-retort underfeed stokers, resulted in average boiler efficiency of 85 per cent and annual saving of $40,000.

SUPERHEATERS

Recent Developments in. Recent Developments in Superheating, J. S. Evenden. Machy. Market (Lond.), no. 1502, Aug. 16, 19, pp. 21–23, 4 figs. Design, manufacture, and operation problems of superheaters are discussed; intertube single-pass superheater arrangement is explained, use of welding operations in manufacture.

T

TUBES

Steel, Handling. Handling Steel Tubes Into Storage With One Operator. Iron Age, vol. 124, no. 11, Sept. 12, 1929, p. 666, 3 figs. Method employed by Spicer Manufacturing Co., Toledo, Ohio, for handling steel tubes is briefly described; using combination of overhead carrying device and permanent stacking rack, steel tubes in loads up to 2 tons are handled from unloading platform to storage and thence to point of use.

W

WAGES

Wage-Payment Plans. The Point System of Wage Payment, R. M. Barnes. Factory and Indus. Mgmt., vol. 78, no. 3, Sept. 1929, pp. 566–568, 2 figs. Article deals with practical setting of standards and computations of earnings under point plan of payment which, it is stated, forms means of analyzing and controlling cost, efficiency and compensation of direct and indirect labor in factory and office.

WELDING

Electric. See ELECTRIC WELDING, ARC.

WELDING MACHINES

Operations on. Cutting and Welding Steel Parts to Replace Castings, W. J. Buchanan. Am. Welding Soc.—Jl., vol. 8, no. 9, Sept. 1929, pp. 61–70, 14 figs. List of wide variety of production jobs that can be performed on welding machine; operations required for various machinery parts are described.

WELDS

Metallographic Study of. A Metallographic Study of Some Metallic Arc Welds, H. M. Boylston, A. Jenkin, and J. C. Carpenter. Am. Welding Soc.—Jl., vol. 8, no. 9, Sept. 1929, pp. 26–47, 27 figs. Experiments described, deal with variables which affect structure of weld; in addition, metallographic examination, physical tests, and bend tests were made from which allowable working stress has been calculated by Kinzel formula; experiments were confined to 6 different welding conditions. Bibliography.

WIND POWER

Utilization of. Rational Utilization of Wind Power (L'utilisation rationnelle de la puissance du vent), M. Neu. Société Française des Electriciens—Bul. (Paris), vol. 9, no. 94, June 1929, pp. 570–574. Advantages and disadvantages; wind motors manufactured in Germany and France; equipment in existence and planned installation of 6000 kw. in Leipzig; production of electric power by means of wind power.

WIND TUNNELS

Motor Control for. Motor Control for Wind Tunnel, W. A. Lewis. Am. Inst. Elec. Engrs.—Jl., vol. 48, no. 9, Sept. 1929, pp. 686–691, 8 figs. Wind tunnel for testing model airplanes and their parts requires accurate control of air velocity; describes tunnel having electric drive for producing air movement and explains system of control, which alloys wide range of speeds and holds speed very constant at any set value; either hand or automatic regulation may be employed; hand control is used for fairly constant speed while automatic control gives very close regulation.

WOOD

Fire Resistance of. A New Test for Measuring the Fire Resistance of Wood, T. R. Truax and C. A. Harrison. Am. Soc. Testing Matls.—Reprint from Proc., vol. 29, pt. 2, 1929, 16 pp., 6 figs. Description of Forest Products Laboratory fire-tube apparatus; tentative procedure for testing inflammability of wood and effectiveness of various fire-retardant treatments; fire resistance is expressed in percentages of loss in weight and increase in temperature resulting from combustion of specimen of uniform dimensions.

WROUGHT IRON

Properties. Comparative Properties of Wrought Iron Made by Hand-Puddling and by "Aston" Process, H. S. Rawdon and O. A. Knight. Metals and Alloys, vol. 1, no. 2, Aug. 1929, pp. 46–55 and (discussion), pp. 55–56, 13 figs. Need for more economical methods in manufacture of wrought iron is pointed out; explanation is given of Aston process; results of chemical analysis of metal at different stages of process are given; results obtained in comparison with properties of iron made by hand puddling and by Aston process.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y.

Volume 51 | November, 1929, Section Two | Number 11

What It's All About

HALF a century ago in America, mechanical engineers became sufficiently conscious of the need for knowledge and cooperative effort in their profession to organize The American Society of Mechanical Engineers. Among its many functions the Society has provided the means for recording the experiences of engineers for the benefit of those who may later face similar problems. Representing a literature rich in technical detail and varied as to subject-matter, the publications of the Society perform a valuable educative service to mechanical engineers. In the Society's journal, MECHANICAL ENGINEERING, which goes to every one of the 19,000 members, are articles covering the widely diversified field in which the interests of mechanical engineers lie. This single-sheet summary of the contents of the November issue tells "what it's all about."

Robert Henry Thurston

PROMINENT in the early history of the A.S.M.E. as one of its founders was Robert Henry Thurston, engineer, educator, researcher, and first president of the Society. To a generation of older men, Dr. Thurston was known as the distinguished head of the department of mechanical engineering at Stevens Institute of Technology, and later as director of Sibley College, Cornell University. One of Dr. Thurston's former colleagues, and a past-president of the A.S.M.E., Dr. Wm. F. Durand, has written his biography. In MECHANICAL ENGINEERING for November appears a brief account of Dr. Thurston's life and contributions to engineering, prepared in anticipation of the publication by Houghton Mifflin Company of the biography by Dr. Durand.

Flying in the Arctic

ROMANTIC contrast—huskies and airplanes—gives mute evidence of technical advance in travel on the cover of the November issue of MECHANICAL ENGINEERING. Man's latest, and surely one of his earliest, means of transportation, separated in the evolutionary advance of civilization by many centuries, are pictured side by side. There is an especial appropriateness in this picture, used in connection with a lecture on "Flying in the Arctic Regions," by Vilhjalmur Stefansson published in the November issue of MECHANICAL ENGINEERING, because Mr. Stefansson makes out a very good case for the airplane in this service.

Mr. Stefansson shows also that the routes between the larger cities of this continent and northern Europe and Asia pass naturally through a region which, while generally considered inaccessible and hazardous, offers abundant landing fields and relatively short lines of travel.

The Amphibion

IT SEEMS to have been a simpler problem for Nature to develop the amphibian than it has been for aeronautical engineers to develop the amphibion. The design of a suitable landing gear has presented difficulties which are only now being comprehended and solved. Igor I. Sikorsky, one of the successful designers of amphibions, states in an article in the November issue of MECHANICAL ENGINEERING that almost every detail of the plane must satisfy a larger number of requirements than do those of other types of planes. The advantage, however, of being able to land and take off from the water as well as the ground is particularly attractive, as most centers of human activity are adjacent to a navigable body of water and greater safety in event of forced landings is obvious.

Laws of Flow

WISHING to establish some basic uniformity in processes that they are analyzing, engineers are accustomed to seize upon some property of a substance, such as pressure, volume, or temperature, which appears to remain fairly constant during the process. In a closed tank it may be safe to assume that the volume is constant, and in a boiler it may be desirable to consider evaporation as taking place at constant pressure. But there is another feature of thermodynamic processes which is uniformly characteristic of many of them—that of flow.

Starting with this point of view, C. Harold Berry, of the Harvard Engineering School, developed the fundamental equation of flow in a lecture which he delivered at the S.P.E.E. summer school for mechanical engineering teachers held at Purdue University early in the summer, and subsequently showed how it could be applied to all manner of problems in which flow was a common characteristic. This lecture has been rewritten for publication and appears in the November issue of MECHANICAL ENGINEERING.

The Cost of Power

IGNORANCE of costs causes many commercial failures. Ignorance of what constitutes the proper basis for figuring costs of power is responsible for much loose talk on the part of uninformed demagogues. As a basis for intelligent consideration of the factors that enter into the cost of power, Mr. C. F. Hirshfeld, chief of the research department of the Detroit Edison Company, has analyzed the problem in a lecture entitled "Factors Affecting Power Cost," delivered at the S.P.E.E. school for mechanical engineering teachers held at Purdue University early in the summer. The lecture is published in the November issue of MECHANICAL ENGINEERING.

Limiting himself to the factors affecting the cost of power as prepared for shipment to the consumer, not as

delivered to him, and to fuel-burning stations, Mr. Hirshfeld discusses (1) investment, (2) utilization of investment, and (3) operating costs.

Stresses in Pipe Bends

TWO years ago at the Annual Meeting of the A.S.M.E., A. M. Wahl, Westinghouse research engineer, analyzing stresses and reactions in expansion pipe bends, called particular attention to the effect on the bend of the flattening of the cross-section of the pipe. Taking account of this ellipticity, Mr. Wahl was able to develop a theory which gave results more nearly in accord with the actual measurements that he made on small bends constructed of seamless tubing than were those determined by other theories.

In the November issue of MECHANICAL ENGINEERING Mr. Wahl, collaborating with J. W. Bowley of the Westinghouse Company and J. Back of the Bureau of Standards, reports the results of a recent test in which actual steam-gage measurements were made on a pipe bend in 10-in. pipe subjected to bending and to internal pressure. Close agreement with Mr. Wahl's previously published theory was demonstrated. It was shown that considerable stress was set up in the pipe by internal pressure because of the initially elliptical form of the cross-section. When these stresses are augmented by the bending stresses, the result may be excessive reactions on anchors and turbine casings.

Deep-Well Pumps

WATER SUPPLY in some sections of the Southwest is obtained from wells rather than rivers and lakes, and as greater numbers of such wells have been driven and more water taken out of the ground, the water level has dropped so that in certain places it is as low as 500 ft. below the ground. To raise the water to the ground has required the use of deep-well pumps, some of which are used in wells 500 ft. deep.

In the November issue of MECHANICAL ENGINEERING, W. H. Holcomb, manager of the pump department of the Pelton Water Wheel Co., San Francisco, writes on "The Development of the Deep-Well Turbine Pump." As a result of extensive research in this type of pump, efficiencies have been raised from 50 to 55 per cent to 65 to 75 per cent.

Thin-Walled Pressure Vessels

MANY investigators have studied the state of stress in thin-walled pressure vessels in attempts to provide the designer of such vessels with a rational basis for design. In the November issue of MECHANICAL ENGINEERING, W. M. Coates, instructor in engineering mathematics at the University of Michigan, develops a rapid method of analyzing stresses which yields results in agreement with those obtained by other methods and by experiment. Mr. Coates shows that the stresses set up by the reactions at the junction of head and cylinder are important and may be computed. The zone of their importance is lengthened by an increase in the thickness of the plate of which the vessel is made. The method which Mr. Coates presents permits a close prediction of the stresses that will be set up when the vessel is subjected to internal pressure.

Woodworking Machinery

IT SEEMS a far cry from period furniture to mechanical engineering, yet just as fine hand tools made it possible for Heppelwhite and Chippendale to express their art as cabinetmakers, so machinery is making it possible to produce beautiful furniture with speed and economy. Admitting that men who were not artists and in whom the esthetic sense found no response produced by means of machinery furniture that was hideous, it can still be maintained that machinery brings as many triumphs to art as it brings failures.

In the November issue of MECHANICAL ENGINEERING, J. D. and Margaret S. Wallace carry the reader "From Early Cabinetmakers to Woodworking Machinery." Their paper, which is to be presented at the Annual Meeting of the A.S.M.E. in December, is illustrated with examples of early cabinet work, hand tools, and woodworking machines.

The March of Progress

THE literature of the classics is found between the covers of books. It is a monument to the glories that have passed, a record of civilizations and cultures that have succumbed to progress and left their feeble impress upon our present thought.

The literature of engineering is the literature of progress. It is found in magazines and pamphlets. It reaches like a searchlight into the future, cutting a pathway of light into the darkness of the unknown. It is the clearing house through which workers and searchers the world over distribute the precious currency of knowledge.

Every month MECHANICAL ENGINEERING puts its readers in touch with the march of progress in engineering by publishing the Survey of Engineering Progress. This department is devoted to abstracts of significant articles published in the engineering literature of the entire world. It is a review of attainment and a mine of new ideas.

Every month, also, eight pages of selected items from the mechanical engineering section of the Engineering Index are published. The items appearing in MECHANICAL ENGINEERING represent only a small percentage of the total number comprising the complete index. In fact, the number of items that it is possible to publish in MECHANICAL ENGINEERING every month barely equals the total number prepared every day from the 1700 publications in 27 languages which pass through the editorial department of the Engineering Index. So complete is this service now that it may be said that "if it is not in the Engineering Index it has not been published."

These are some of the contributions which The American Society of Mechanical Engineers is making to assist the march of progress.